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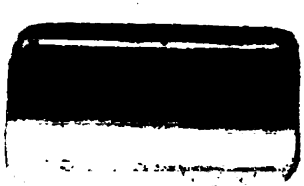

REPORT

OF THE

SELECT COMMITTEE

ON

ORDNANCE AND WAR SHIPS,

WITH

AN APPENDIX.

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ORDNANCE AND WAR SHIPS.

RY SITY RNIA.

IN THE SENATE OF THE UNITED STATES.

Mr. HAWLEY, from the Select Committee on Ordnance and War Ships, submitted the following

REPORT:

This select committee was appointed under the following resolution:

Resolved, That a select committee of five Senators be appointed by the Chair to inquire as to the capacity of steel-producing works in the United States to make steel of suitable quality and sufficient in quantity to furnish metal for guns of high power, and metal plates and other material for the construction of vessels of war, and for the armor or sheathing for such vessels.

2. That said committee shall also inquire as to the character and sufficiency of machinery and machine-tools in the navy-yards, and also in private foundries and machine shops in the United States, for the construction of engines suitable for vessels of war, and for manufacturing guns for the proper armament of such vessels, and of the seacoast defenses, and for the purpose of constructing iron and steel ships of war.

3. Said committee shall also inquire into the best locations in the United States for manufacturing guns, engines, and armor for vessels, and for building iron and steel ships of war, and the best method of manufacturing and building the same, whether by the Government or by contract with private persons.

4. Said committee shall have power to sit in the vacation of the Senate at any place in the United States, to send for persons and papers, and to appoint a clerk, stenographer, and messenger, and may report by bill or otherwise.

5. The expenses of said committee, and of witnesses summoned before it, shall be paid out of the contingent fund of the Senate, to be certified by the chairman of the committee, and audited and allowed by the Committee to Audit and Control the Contingent Expenses of the Senate.

Agreed to July 3, 1884.

The following Senators were appointed: Senators J. R. Hawley, J. F. Miller, N. W. Aldrich, John T. Morgan, and M. C. Butler. Mr. Miller was excused from further service at his own request March 24, 1885, and Mr. Sewell was appointed to fill the vacancy March 30, 1885.

The committee having been unable to complete its inquiries during the recess of 1884, the Senate adopted the following resolution:

Resolved by the Senate, That the select committee "to inquire as to the capacity of steel-producing works in the United States," be continued, with leave to complete the duties assigned to them by the resolution of the Senate, and with the powers conferred upon them heretofore by the Senate, and that they report to the Senate at the session in December, 1885.

Agreed to March 3, 1885.

In some cases the full committee, in others a subcommittee, visited the following companies, works, and yards:

The Morgan Iron Works, New York City; the Continental Iron Works, Greenpoint (Brooklyn), N. Y.; the West Point Foundry Association, Cold Spring, N. Y.; the Midvale Steel Company and the ship yards of Cramp & Sons, Philadelphia; the Cambria Iron Company, Johnstown, Pa.; the Bethlehem Iron Company, Bethlehem, Pa.; the Pennsylvania Steel Company, Steelton, Pa.; the ship-yard of John

Roach & Son, Chester, Pa. At Pittsburgh: the Edgar Thomson Steel Works, the Pittsburgh Bessemer Steel Works, the Homestead Steel Works; Park, Brother & Co., limited; the Pittsburgh Steel Casting Company; Jones & Laughlin's; Miller, Metcalf & Parkin, and the Keystone Bridge Company. The South Boston Iron Works, Boston, Mass.; the Tredegar Iron Works, Richmond, Va.; the navy-yards at Norfolk, Washington, and New York; the Army ordnance proving grounds at Sandy Hook, N. J.; the naval ordnance proving grounds at Annapolis; and the torpedo station at Newport, R. I.; also witnessing there the maneuvers of the North Atlantic squadron in August, 1884.

Two members of the committee, in England during the past summer on private business, took opportunities, one or both, to visit the Woolwich Arsenal, the Chatham Dock-Yard, the proving grounds at Shoeburyness, and the works of Sir William G. Armstrong & Co. and R. & W. Hawthorn, at Newcastle-on-Tyne, Charles Cammell & Co. and Sir John Brown & Co., at Sheffield, and Sir Joseph Whitworth & Co., at Manchester.

Through Mr. Phelps, the minister of the United States, official permission was kindly and promptly granted to visit the Government works at Woolwich, Chatham, and Shoeburyness, and the private establishments were opened most frankly and cordially. The subcommittee was accompanied by Commander Chadwick, naval attaché of the United States legation, and Lieutenant Jaques, U. S. N., both specially qualified for such guidance.

Mr. Morgan, of the committee, visited the Pacific coast and inspected the Mare Island navy-yard, the Union Iron Works, and the Pacific Rolling Mill Company's shops.

At the request of the committee, the Navy Department detailed Lieut. W. H. Jaques, and the War Department Capt. Charles Shaler, Ordnance Corps, to assist in its inquiries, both highly capable officers. The services of both were not required, and Lieutenant Jaques served as secretary throughout the investigation. The committee acknowledge with great pleasure his ready, varied, and accurate information, and his thorough devotion and fidelity.

The committee addressed circulars of inquiry covering the matters embraced in the resolution to a large number of manufacturers. In some cases where they could not visit the manufactories, or could not delay to take full notes on the spot, they sent a series of questions by mail. The responses appear in the appendix. There also may be found the testimony or statements, of eminent manufacturers, scientists, and others who appeared in person before the committee or forwarded written papers, and likewise various extracts from official reports, American and English, and various summaries prepared by the secretary of the committee under its direction.

We append also a brief descriptive catalogue of recent publications, official and unofficial, which give the latest information and opinions concerning the subject of this inquiry and its related topics.

IRON ORES IN THE UNITED STATES.

In proceeding to ascertain the capacity of the steel-producing works of the United States, the locations and characteristics of the iron ores of the country claim a brief preliminary consideration.

The ores found on the Pacific coast have received but little attention, but some of them, abundant in quantity, are excellently adapted to steel making, containing slight quantities of phosphorus. Most of the

deposits are on well-timbered land, and manufacturers in California declare that nothing is lacking but a demand for the product.

Excellent steel-making ores are developing in Colorado.

The celebrated Marquette district, in Michigan, is the most productive in the country. The extent, richness, and purity of the hematite and magnetic ores of this region are remarkable. Fourteen analyses of ores from one of the most noted mines show that they average 68.48 per cent. of metallic iron.

Next to the Marquette district in productiveness is the Menominee range district, in Michigan and Wisconsin. Its ores average from 64 to 67 per cent. of metallic iron.

During the twenty-eight years ending in 1884 the total production of iron ore on the southern shore of Lake Superior amounted to 25,313,244 tons.

Ores of vast extent and uniformly good quality have lately been developed in the Lake Vermillion district, in Saint Louis County, Minnesota.

There are four distinct iron-ore fields in Missouri, whose products exhibit from 59 to 68 per cent. of iron.

The immense Cornwall ore beds of Lebanon County, Pennsylvania, appear to be no nearer exhaustion than when they were opened one hundred and fifty years ago.

The Salisbury iron region of Litchfield County, Connecticut, and neighboring counties in New York and Massachusetts, supplies valuable brown hematite ores as freely as in the last century.

The State of New York is very rich in ore along its eastern border on both banks of the Hudson and in the vicinity of Lake Champlain.

Northern New Jersey has a number of mines, chiefly of magnetic ore, furnishing an iron suitable for forge or foundry purposes, with some well adapted to the manufacture of Bessemer steel.

Ohio has many varieties of iron, but Ohio, like Pennsylvania, makes more iron from ores mined outside its borders than from its own ores.

West Virginia, Kentucky, Tennessee, Georgia, and Alabama contain valuable and extensive deposits, some of which have furnished iron of celebrated excellence. Under the new and rapidly improving processes many of these ores can be converted into steel.

Iron ore is common in Virginia, some of very superior quality.

North Carolina has many deposits, one of which, in Mitchell County, has acknowledged superior adaptability to the manufacture of steel.

The pig-iron produced in the United States in 1884 amounted to 4,067,868 gross tons, which, by trade estimates, required 7,785,940 tons of ore. Deducting the importations, 487,820 tons, we have 7,298,129 as the home production of the year that was smelted. The production of steel in the United States in 1883 was as follows:

	Short tons (2,000 pounds).
Bessemer (acid)	1,654,627
Open-hearth	133,679
Crucible	80,455
All other steel	5,598
Total	1,874,359

The production in 1884 was as follows:

Bessemer (acid)	1,540,595
Open-hearth	131,617
Crucible	59,662
All other steel	5,111
Total	1,736,985

Nearly one-third of the ore is suitable for Bessemer steel, according to the arbitrary standard assumed, which excludes such as contain more than one-tenth of 1 per cent. of phosphorus.

OPEN-HEARTH STEEL.

All the ores available for Bessemer steel are available for the open-hearth or Siemens-Martin process. It is the final and decided judgment of the practical gun-makers that open-hearth steel is best adapted for heavy guns and armor.

For a list of the open-hearth steel makers of this country in 1884, see Appendix, p. 232. The casting capacity of some of them is as follows:

The Pennsylvania Steel Company has two thirty-ton furnaces, capable of producing 4,000 tons a month. The Cambria Iron Company has three Pernot revolving hearth furnaces; the product of the two sixteen-foot furnaces has reached 25,000 tons a year. The Midvale Steel Company has three furnaces, in which 35 tons of steel can be melted at one time. The Bethlehem Iron Company has two Pernot furnaces, each of twenty tons capacity. The Otis Iron and Steel Company has a yearly capacity of 40,000 tons, and Park Bros. & Co. (limited), of Pittsburgh, of 20,000 tons.

The total production of open-hearth steel in this country in 1883 was 133,689 short tons, but in 1882 there was made 160,542 tons, and their present estimated capacity is 550,000 net tons of ingots per annum.

The production and characteristics of American ores are compactly set forth in the papers and diagrams of Messrs. Powell, Williams & Swank, in the appendix.

IMPORTED ORES.

Foreign ores are imported in considerable quantities, and used in furnaces within easy reach of tide-water. This is partly due to the low prices of the foreign article and partly to the smaller percentage of phosphorus in certain imported ores which are mingled with native ores containing more than the permissible percentage.

There has been more dependence upon foreign sources for manganese and the spiegel made therewith, which are indispensable in the manufacture of steel, but owing to the low price of foreign spiegel, and the fact that it does not form a very large item of the cost of steel, enough attention has not been paid to the development of manganesic ores, of which the country has a sufficient supply, nor to the manufacture of spiegeleisen. However, the home production of the latter is rapidly increasing.

SUMMARY RELATING TO ORES AND STEEL MANUFACTURE.

Referring for the details to the evidence in the Appendix, it may be summarily said:

1. That iron ores are found in a large majority of the States and Territories of the Union accompanied by all the elements necessary for their reduction. In some localities the materials are so closely assembled that the cost of converting them into steel will probably be less than in any other part of the world.

2. That the present state of steel manufacture in the country enables us to produce steel in abundant quantities, and a still greater production would answer quickly to a demand many times greater than any that the national Government is asked to make or needs to make.

But it must be borne in mind that the evidence we submit shows that no private or public establishment is prepared to furnish the heavy masses of metal needed for the guns that are accepted by other nations as the best types, nor for the shafting and the heavy armor plates placed on the latest ships, or for the turrets and casemates of shore defenses. Our steel makers stand ready to contract to furnish all such, however, and entertain no doubt of their ability to reproduce all the latest and costliest machinery that is needed to manufacture such metal of the best character. They lack the experience that is needed for the immediate, perfect production of the steel best adapted for heavy guns and armor, but the extraordinary ease with which they have always learned whatever they had sufficient commercial inducement to learn, justifies the confidence with which they promise to supply, in quality as well as in quantity, whatever the Government shall require.

MACHINERY IN THE NAVY-YARDS.

Your committee is instructed to inquire as to the character and sufficiency of machinery in the navy-yards for constructing guns, engines, and ships. In response to the request of the committee Secretary Chandler submitted a communication (Appendix, pp. 33–48) in which he discusses the whole subject, liberally quoting from and approving the report of the Gun Foundry Board (pp. 34 *et seq.*).

Your committee's examination and inquiry discovered in the different navy-yards a large number of tools adapted to the building of engines and boilers of the largest description, but many of them are old and incapable of performing economically the work required at the present time. They cannot therefore be presented as constituting the adequate plants intended in the resolution, although they are large and expensive.

We give extracts (Appendix, p. 133) from the report of the Commission on Navy-Yards, dated December 1, 1883, and contained in Senate Ex. Doc. No. 55, Forty-eighth Congress, first session, which present their principal recommendations and the condition and capacity of the plants at the various navy-yards, together with a tabulated statement showing the area, cost of site, and improvements of each navy-yard and station, as well as the present value of site, improvements, machinery, and personal property of each June 30, 1882.

It will be seen from an inspection of these that there are no less than seven different yards over which expensive tools for the building of engines and boilers are distributed, while but one has plant for the "fabrication" of modern heavy ordnance, and none of them has a suitable plant for the manufacture of the rough parts of heavy guns or for the construction of steel ships.

In consideration of which, we concur in the recommendations of Secretary Chandler and the Navy-Yard Commission that there should be a concentration of the plant and work in such yard or yards as may have the best facilities for the repairs of engines.

It would appear that more economy and efficiency would be obtained by such a disposition of the marine engineering machinery of at least four of our yards as would make the *remaining* plants of construction, steam-enginery, and ordnance more useful. For example, some of the marine-engine plant at the Washington navy-yard would supplement the gun-factory plant that has been partially developed at this yard for finishing and assembling heavy steel guns. The work at this yard should be limited, if not to ordnance alone, certainly to ordnance and equip-

ment, and all other work should be transferred to New York or such other yard as may be selected for construction and the building of engines and boilers, unless the policy of giving the work to private contractors should be adopted.

The Washington navy-yard contains the best gun-fabricating plant in the United States, and was selected by the Gun-Foundry Board as the best adapted for the establishment of a naval gun factory. A number of heavy steel guns are in hand, including two ten-inch guns weighing 54,000 pounds each. These guns and the more valuable parts of the plant for finishing them are specified in the note to page 136 of the Appendix.

Our extracts from the report of the Navy-Yard Commission of 1883 show that while the Mare Island, Portsmouth, Boston, Brooklyn, Washington, Norfolk, and Pensacola yards have the facilities for building wooden hulls, only one, the New York yard, is mentioned as having even a "fair" plant for the construction of hulls of metal.

Your committee, being instructed to extend to the private foundries and machine-shops its inquiry as to the character and sufficiency of machinery and machine-tools for the construction of guns, engines, and iron and steel ships, throws light upon the subject, so far as guns are concerned, by giving the following statement of the

CURRENT WORK ON HEAVY GUNS.

The Ordnance Department of the Army have in progress of manufacture, in accordance with the provisions of the act of March 3, 1883, the following heavy guns:

One 12-inch cast-iron B. L. rifle, hooped and tubed with steel. Body, South Boston Iron Company; hoops, Midvale Steel Company; tube, Whitworth & Co.

One 12-inch B. L. rifle, cast iron lined with wire-wrapped steel tube. Body to be cast by South Boston Iron Company; tube, Whitworth & Co.; to be wire wrapped at Watertown Arsenal.

One 10-inch B. L. rifle, cast iron, wrapped with wire. Body, South Boston Iron Company; to be wire wrapped at Watertown Arsenal.

One 10-inch B. L. rifle, steel, wrapped with wire. Tube, Whitworth & Co.; rough bored, turned, and annealed at Washington navy-yard; longitudinal bars cold rolled at Jones & Laughlin's, Pittsburgh, and annealed at Washington navy-yard; to be wire wrapped at Watertown Arsenal.

One 8-inch steel B. L. rifle. Tube and jacket, Whitworth & Co.; hoops, Midvale Steel Company; fabrication, West Point Foundry Association.

One set of forgings for 8-inch steel B. L. rifle. Midvale Steel Company.

One 10-inch B. L. rifle, steel hooped. Tube, jacket, and trunnion-hoop, Whitworth & Co.; hoops, Cambria Iron Company.

Fifty converted 8-inch muzzle-loading rifles from 10-inch smooth-bore guns. Steel tubes, Midvale Steel Company; conversion, West Point Foundry Association.

One steel siege 5-inch B. L. rifle. Forgings, Midvale Steel Company; fabrication, Watertown Arsenal.

The Ordnance Department of the Navy have made no conversions of the Dahlgren 11-inch smooth-bores to 8-inch muzzle-loading rifles since January, 1880. All of the guns under fabrication at the Washington navy-yard and by contract are modern, all-steel, high-power rifles.

Navy-yard, Washington, D. C.

[Kind: B. L. steel rifles.]

No.	Caliber.	Forgings supplied by—	Remarks.
	Inches.		
2	5	Midvale Steel Company	Being tested.
10	6	Midvale Steel Company	Six being tested; others nearly completed.
4	8	Cammell & Co., Sheffield, England	One being tested; others nearly completed.
2	10	Whitworth & Co., Manchester, England	
1	10½	Whitworth & Co., Manchester, England	

All of the rough boring and turning for these guns was done at the Washington navy-yard.

By contract.

[Kind: B. L. steel rifles.]

No.	Caliber.	Forgings supplied by—	Contract with—	Remarks.
	Inches.			
6	6	Midvale Steel Company	South Boston Iron Company	Contract of August, 1884; work expected to be finished May, 1886. All of the rough boring and turning for these guns done at the Washington navy-yard.
2	8	Whitworth & Co., Manchester, England.		
5	6	Midvale Steel Company	West Point Foundry Association.	
2	8	Whitworth & Co., Manchester, England.		

It will be noticed that all the heavy parts of the large steel guns are supplied by English makers. No navy-yard and no private establishment in the country has the plant for forging all the parts of a steel gun above the caliber of six inches. It should be observed that the term "fabrication" is usually technically applied only to the final fine boring, rifling, turning, and putting together, or "assembling." An exception should be made in favor of the enterprising Midvale Steel Company, which is making a set of forgings for an eight-inch breech-loading rifle.

MARINE ENGINES.

As to the facilities for the manufacture of marine engines in private shops, there is no lack of them, for while our steamships engaged in foreign trade are comparatively few, the total number of our steam vessels is 5,399, with an aggregate tonnage of 1,494,916 tons. Among their engines are many unsurpassed in their classes.

SHIP-BUILDING.

The evidence submitted herewith also shows that iron and steel ships of war can be built in the United States. Builders of extensive and successful experience stand ready to contract to build as fast as the Government is likely to order. It must be understood that we except the heavy armor and shafting, which cannot at present be forged in the United States.

It should also be said that the latest vessels of the best types built by foreign nations, especially those heavily armored and carrying guns up to the weight of 110 tons, are the results of many costly experiments, and in their special features require a certain skill and knowledge which our builders have had no opportunity of acquiring. In like manner it should be noted that for twenty years our engines have mostly been built for the peaceful purposes of commerce. In that work, while great speed has sometimes been sought and obtained, the problem before the builder differed widely from that set before the constructor of engines for ships of war, who has been required to exhaust genius in giving them gigantic power with reduced weight, and placing them as far as possible out of harm's way.

Weighted by these conditions, and stimulated by fierce competition and generous rewards for success, foreign builders have rapidly perfected their work and are struggling close to twenty knots an hour, while their merchant ships, devoted to the freighting of goods alone,

find that their most profitable rates of speed range between ten and thirteen knots. Nevertheless, the history of our Navy in the days when patriotism demanded exertion to have a navy, shows that the ships of the United States were in the first rank. They can be placed there again when the nation demands it.

LOCATIONS FOR MANUFACTURING AND BUILDING.

Our next inquiry relates to the best locations for manufacturing or building guns, engines, armor, and iron or steel ships, and the best methods of such production, whether by the Government or by contract with private persons.

We may briefly dispose of the question as to ships. The war ships of the future will be built of steel, save that gunboats and partially-protected sloops, mostly of moderate tonnage, may be composite, or constructed of steel frames planked with wood.

Some of these vessels may be built in our navy-yards, after a comparatively moderate expenditure for improvements of the plant. The evidence before us shows that ships built in Government yards invariably cost more than private parties would ask for them, and some of the causes of this difference are not likely to be eliminated. For the vessels built in navy-yards the steel frames and all other metallic parts would be necessarily furnished by private manufacturers. But the larger number of vessels could best be obtained of private builders.

The vital importance of protecting the Pacific coast must not be overlooked. The Mare Island navy-yard has a very large and excellent dry-dock, well advanced towards completion. It should also have full and modern facilities for extensive repairs. It would be wise to put the yard into condition also to build certain classes of ships.

ENGLISH EXPERIENCE.

The British Government has lately reviewed its policy in ship-building by the help of a "committee on the building and repairing of ships," whose report was submitted to parliament in October, 1884. The committee was instructed to inquire into "the conditions under which contracts are invited for the building of ships and their engines, the selection of firms, relative cost of government and private work, and the mode in which repairs are effected in dock-yards." The policy of building most of their ships by contract was amply sustained by the voluminous evidence, but the committee held that the efficiency of the dock-yards should not be reduced, and that all repairs should be made therein. We give very nearly the whole report in the Appendix, p. 49. As further throwing light upon the subject, we give examples of the specifications and forms of contracts used by the British Admiralty and a contractor's specifications for a ship built for a foreign government, pp. 56–102.

In the Appendix (page 103) may be found an official "return respecting the ships built and building for the British navy, 1880 to 1885," including a statement of some vessels proposed for 1885–'86. The details concerning armor, guns, engines, horse-power, tonnage, speed, and cost are instructive. (See also pp. 104–118.) The extent to which the Board of Admiralty contracts with private parties may be seen. A considerable number of vessels are constructed in the dock-yards, but all the iron and steel parts, armor included, are supplied in shapes by private shops.

It will be noticed that every engine, without exception, comes from private contractors. This has long been the English practice and the influence of extreme demands from the Admiralty, vigorous competition and the lifelong labors of mechanics of genius have secured unsurpassed results. (See Appendix, p. 15.) The locations for building ships would be partly in the navy-yards, but chiefly in private establishments. Engines should be built by the private contractors who can give the best results.

PRESENT ARMAMENT OF THE ARMY AND NAVY.

In considering the best locations for manufacturing guns and armor, and the choice between Government and private work, it is well to see first what we have and what the future supply ought to be.

The Army has in forts and arsenals:

Smooth-bores:		
20-inch caliber	2	
15-inch caliber	308	
10-inch caliber	998	
8-inch caliber	210	
		1,518
Parrott rifles:		
10-inch caliber, 300 pounders	38	
8-inch caliber, 200 pounders	81	
6.4-inch caliber, 100 pounders	173	
		292
Converted from 10-inch smooth-bores to 8-inch rifles	160	
Ditto under contract for conversion	50	
		210
Smooth-bore mortars		45
		2,065

These are all muzzle-loaders. The nine classes require thirty-three kinds of ammunition. They are totally inadequate to the defense of our most important harbors. They may be utilized in the protection of harbors admitting only vessels of light armor and draught, and even there they should usually be supplemented by the modern breech-loading steel rifle, with its more rapid and efficient fire.

The number of serviceable naval great guns is:

Smooth-bores:		
20-inch caliber	3	
15-inch caliber	76	
11-inch caliber	357	
10-inch caliber, shell	12	
10-inch caliber, shot	21	
9-inch caliber	1,011	
8-inch caliber, 6,500 pounds	346	
32-pounders, 4,500 pounds	378	
		2,204
Parrott muzzle-loading rifles:		
150-pounders	28	
100-pounders	267	
60-pounders	75	
30-pounders	375	
20-pounders	245	
Dahlgren muzzle-loading rifles, converted from 11 inch to 8 inch	50	
		1,040
Parrott breech-loading rifles:		
80-pounders	9	
60-pounders	27	
30-pounders	5	
		41
		3,285

To these must be added 10½, 10, 8, 6, and 5 inch breech-loading, built-up, forged-steel rifles of the latest type for the monitors and new cruisers, as follows:

Steel breech-loading rifles:	
5-inch caliber	2
6-inch caliber	21
8-inch caliber	8
10-inch caliber	2
10½-inch caliber	1
	34

Ten of these are finished, and it is promised that the remainder shall be ready in May of this year. The twenty-two classes require thirty kinds of ammunition. All save the modern steel rifles ordered for the monitors and cruisers are of classes whose manufacture is abandoned by the nations which have devoted themselves to perfecting cannon.

PROGRESS IN ORDNANCE.

In every detail the advance of the last twenty-five years has been wonderful. The adoption of slow-burning powders, producing greater force with reduced strain, necessitated longer guns, whose use was made possible by breech-loading mechanism, bringing with it an increased rapidity and safety of loading. The attempts to make long rifles of cast iron, or of iron and steel, have been abandoned (and the value of wire-wound guns is still a question), since open-hearth steel and hydraulic forges have made comparatively easy the forging of 75-ton ingots of homogeneous steel, exhibiting the highest qualities required for guns.

The marvelous work of hydraulic forging-presses is described in the Appendix, pp. 23, 24. In the same article may be found a sketch of the process of liquid compression, as practiced by Sir Joseph Whitworth. Whatever the real nature of this work, it is true that the ingots of steel produced thereby are superior to ingots of equal size obtained by any other process.

The culminating result of the last twenty years of scientific experiment may be judged by the accompanying table, whose statistics are of the latest date, obtained for the committee from the highest authorities:

TABLE OF MODERN HEAVY ORDNANCE.

[Prepared for committee by Lieut. W. H. Jaques, U. S. N.]

Nation and nature of gun.	Date.	Caliber.	Weight of gun.	Length of gun.		Weight of charge.	Weight of projectile.	Initial velocity per second.	Muzzle energy.	Energy per ton weight of gun.	Perforation of wr'ght iron at 1,000 yards.	Authorities.
		Inches.	*Tons.*	*Feet.*	*Caliber.*	*Pounds.*	*Pounds.*	*Feet.*	*Foot-tons.*	*Ft.-tons*	*Inches.*	
England:												
*Elswick Ordnance Company, B. L. R.	1883	17	108	46.8	33	382	2,000	2,037	57,555	533	28.7	Captain Noble (Elswick).
Do	1882	17	100	39.7	28	772	2,000	1,835	51,900	519	28.0	Do.
Do	1884	16.25	110	41.8	31	900	1,800	2,020	a50,924	463	30.5	Colonel Maitland, R. A.
Royal Gun Factory, B. L. R.	1884	12.5	63	34.7	31	625	1,250	2,050	36,415	578	28.6	Do.
Armstrong B. L. R.	1885	9.2	21	23.9	31	b230	320	2,179	12,840	611	19.3	Captain Noble.
Elswick Ordnance Company (wire), B. L. R.	1884	9.2	18	27.6	36	200	380	2,200	12,759	709	20.0	Colonel Maitland, R. A.
Royal Gun Factory (wire), B. L. R.	1884	9.2	19	31.2	41	330	380	2,520	16,730	881	23.2	Do.
Whitworth B. L. R.	1883	9.05	20	25.5	29	c197	403	1,900	10,085	504	21.3	Whitworth & Co.
France:												
37 centimètre, B. L. R.	1884	14.56	71	34.8	29	546	{ d1,455 { 1,180	d2,034 1,955	} 31,272	441	24.5	Colonel Maitland, R. A.
34 centimètre, B. L. R.	1881	13.38	52	32.7	30	362	926	1,968	24,868	478	22.9	Colonel Maitland, R. A.
de Bange, 340mm, B. L. R.	1885	13.38	36.9	36.3	33	397	926–1,213	e2,132	.....	.....	.....	Colonel de Bange.
Germany:												
Krupp, 40 centimètre, B. L. R.	1884	15.75	119	44.7	34	615	1,632	2,017	46,061	387	29.2	Colonel Maitland, R. A.
Do	1881	15.75	71	31.4	24	485	1,715	1,703	34,502	486	23.3	Do.
Krupp, 30.5 centimètre, B. L. R.	1883	12	48	32	32	357	1,008	1,857	23,905	498	23.3	Bureau Army Ordnance.
Italy:												
Armstrong, 45 centimètre	1880	17.42	100	32.7	23	551	2,000	1,700	40,079	401	25.3	Captain Noble.
Armstrong, 43.18 centimètre, B. L. R.	1883	17	100	39.7	28	772	2,000	1,835	51,900	519	28.0	Do.
United States:												
Bureau of Naval Ordnance, B. L. R.	{ 1885	10.5	30	30.7	35	275	550	2,100	16,810	564	20.3	Bureau Naval Ordnance.
	{ 1885	10	26	27.4	33	250	500	2,100	15,355	632	19.9	Do.
Do	1885	8	12.8	21.4	32	125	250	2,075	7,462	606	15	Do.
Do	1885	6	4.9	16.1	32	50	100	1,915	2,542	518	9.7	Do.
Do	1885	5	2.8	13.4	32	30	60	1,915	1,525	609	8.5	Do.

* The registered name is now Sir W. G. Armstrong, Mitchell & Co., Ld.
a Captain Noble calculates this at 61,200 foot-tons (1884).
b Cocoa powder.
c Black prismatic powder.
d Lieutenant Weyl, French navy.
e Colonel de Bange estimates this to be probable highest velocity.

Several smaller calibers common to all the nations mentioned are omitted in the foreign statements. With two exceptions, which we regard as still experimental, all these guns are of one type, the long, forged steel, jacketed and hooped, breech-loading rifle.

This may be described in general terms, as follows (see page 137): The first and chief piece is a chambered tube; the second is a jacket extending from the breech, about one-third of the length of the tube, to a point at or just in advance of the trunnions; the remaining pieces are hoops judiciously arranged to resist transverse strain. The trunnion hoop is usually screwed into its position. The jacket and hoops are finished with extreme nicety and shrunk on. An "interrupted screw" (page 10) closes the breech, engaging in the jacket. (In this the German guns—Krupp's—are an exception, closing by a wedge-shaped block pushed through a slot and screwed into position.)

Plate 13 gives a view of the exterior appearance and a half section of the English 110-ton gun, the largest ever finished.

The weights of the parts of heavy steel ordnance are approximately given in the following table of estimates for guns intended for coast defense:

WEIGHTS OF INGOTS, FORGINGS, AND FINISHED GUNS.

[Authority, Capt. C. S. Smith, United States Army.]

Caliber of gun.	Weight of ingot.	Gross weight of heaviest forging.	Finished weight of heaviest forging.	Weight of finished gun.	Remarks.
Inches.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	
6	3.1	1.7	1.5	4.9	Tube, heaviest part.
8	14	7.65	4.07	12.7	Do.
10	25	13.66	7.75	28.	Do.
12	40	23.75	13.22	48.2	Do.
16	*75 †77.5	*45.17	*22.92	121.7	

*Tube. †Jacket.

WHAT GUNS SHALL THE UNITED STATES BUILD?

The "Armament Board" of Army officers (see Sen. Ex. Doc. No. 5, Forty-eighth Cong., second session) in its report of December 5, 1884, being required to determine the character and number of guns required for fortifications and other works of defense, said:

The Board interpreted the act of Congress under which it was appointed to refer only to mortars and guns of high power for the defense of our harbors against foreign armor-clad vessels, and in their investigation have not taken into consideration the lighter guns required for the flank defense of permanent works.

The Board first directed its attention to the depth of water in the channels leading to all of our seaports, and then ascertained the number of and thickness of armor of the known iron-clads of the world which could enter their harbors.

The powers of the guns necessary to penetrate these armors were then calculated and the numbers of guns considered essential for a proper defense of the harbors was decided upon. In that determination the Board was guided by a list of guns and mortars which had been prepared by the Board of Engineers for Fortifications after careful study of the subject.

The decision in regard to the calibers, lengths of bore, and weights of guns and projectiles was made from an examination of the most powerful and approved types of modern guns known in this country and in Europe. The weights of these guns and of their steel armor-piercing projectiles being definitely known, they are not given between limits.

The following tables give, as far as it can be ascertained, the information which the Board is called upon to furnish:

TABLE I.

Caliber.	Number of each caliber.	Length of—			Weight of gun.	Weight of projectile.	Weight of charge.
		Bore.		Gun.			
Inches.		*Calibers.*	*Feet.*	*Feet.*	*Tons.*	*Pounds.*	*Pounds.*
8	125	30	20	21.5	13	286	100
10	226	30	25	26.875	25	575	225
12	306	32.06	32.06	35.11	48	894	456
16	50	31.74	41.67	45.93	107.77	1,631.4	650.4
12" mortar	512	9	9	10.33	13.06	610	52

TABLE II.

Caliber.	Velocity of projectile in feet per second at—							
	Muzzle.	1,000 yards.	2,000 yards.	3,000 yards.	4,000 yards.	5,000 yards.	6,000 yards.	7,000 yards.
Inches.								
8	1,800	1,639	1,488	1,350	1,220	1,129	1,049	995
10	1,900	1,767.7	1,642.2	1,522.3	1,410.9	1,308.5	1,217.5	1,138.6
12	1,853	1,731.2	1,641	1,508.5	1,405.1	1,310.2	1,225.5	1,150.9
16	1,965	1,865	1,750	1,641	1,536.9	1,437.1	1,344.5	1,260.6

TABLE III.

Caliber.	Penetration of wrought iron in inches at—							
	Muzzle.	1,000 yards.	2,000 yards.	3,000 yards.	4,000 yards.	5,000 yards.	6,000 yards.	7,000 yards.
Inches.								
8	16.43	14.97	13.63	12.40	11.31	10.39	9.67	9.19
10	21.08	20.38	18.96	17.61	16.33	15.16	14.13	13.23
12	24.24	22.68	21.31	19.81	18.47	17.25	16.15	15.18
16	30.49	28.96	26.95	25.29	23.71	22.20	20.74	19.52

The Gun Foundry Board (Sen. Ex. Doc. No. 13, Forty-eighth Congress, second session, supplementary report of December 20, 1884, included), composed of Army and Navy officers, was appointed under the act of March 3, 1883, to designate a navy-yard or arsenal for a Government gun foundry, to advise as to the method of manufacturing heavy ordnance adapted to modern warfare, and to estimate the cost of buildings and implements for making the heaviest guns. The Board visited the chief foreign gun foundries, Krupp's excepted. Their report is exceedingly instructive. Though they were not required to decide upon types of guns, their report assumes that we are to build only the class we recommend.

The Fortifications Board (Senate Ex. Doc. No. 43, Forty-ninth Congress, first session), composed of four Army officers, two Navy officers, and two eminent manufacturers, presided over by the Secretary of War, appointed to name the ports most urgently needing fortification, and the kind of defenses best adapted to each, with reference to armament, has just submitted an elaborate report, emphatically recommending the built-up, forged steel gun.

The argument based upon the alleged economy of the cast-iron heavy rifle has been steadily losing force by reason of the constant cheapening of the processes of making gun-steel and the increasing ease of forging it in large masses.

When a comparison is made between two guns giving an equal energy, it is found that the steel gun weighs but little more than half its competitor, and costs but little more. Such are the manifest uncertainties and weaknesses of the cast-iron gun that the argument may be considered closed. This is the emphatic judgment of Europe, and in accepting that judgment this committee concurs with our own officers and experts.

MATERIAL FOR ARMOR.

The long debate over the question whether iron or steel should be used for turrets, casemates, and other shore defenses, and for the armor of ships is still maintained; but that also, it seems to your committee, to be nearly at an end. The great advantage of steel, in giving an equal resistance with a much less weight, decides the question in its favor as to all uses on board ship, where weight is a governing consideration. But for defenses on land wrought iron still has its advocates.

Speaking of such defenses, the Fortifications Board says:

> The materials used in construction for the armor might either be iron or steel, although the latest experiments indicate the superiority of forged steel plates. While the board is of opinion that forged steel plates should be used, it also recommends that immediate experiments be undertaken to determine the most suitable armor for turrets and casemates.

Experiments of the character indicated would require much time and money. We have not the guns nor the armor, and must either purchase or make them, either of which courses would involve a long delay. Concurring in the opinion of the Board that "forged steel plate should be used," we believe that the manufacture thereof should be commenced, postponing the experiments until they could be made with guns and armor of our own manufacture, if, at that time, the question should not be settled.

Although wrought iron is still used in England for forts, steel possesses many acknowledged advantages. It is somewhat more costly per pound, but its power of resistance is so much greater than that of wrought iron that the plate-upon-plate system that will have to be adopted to get the required thickness with the latter, the increased length and cost of bolts, the enormous cost of fitting the plates accurately to each other (which is very essential), the impossibility of doing so when the plates are curved, and the increased cost of transportation tell heavily against the wrought iron, and will increase the cost of wrought iron protection to more than that of the steel plate of an equal power of resistance.

As to compound armor (wrought iron and steel), it is so much more expensive than steel, and the welding is so imperfect because the rolling has a tearing rather than welding effect (as the two materials being differently affected by the work of the rolls), that these reasons would decide the question in favor of steel, even if the latest competitive trials had not shown the latter the victor.

We must conclude, therefore, that the great cost of compound armor, and of sandwiching and accurately fitting wrought iron, added to their inferior resisting power and greater weight and space occupied, clearly demonstrates that *steel* is the proper material for the armor of ships and fortifications. For further discussions of the question, including the use of the Gruson chilled cast-iron armor on shore, see Appendix,

pp. 193–212. See also pp. 24–29 for an illustrated account of the latest comparative tests at Spezia, where the solid steel plate won a brilliant victory over the compound plate.

TORPEDOES.

In considering the proper armament of ships and of coast defenses the torpedo cannot be overlooked. The papers of Lieut.-Commander Barber and Lieutenant Jaques (Appendix, pp. 147–174) give the late history of this weapon. The torpedo board, created in 1883, found itself unable to select a type from the four movable torpedoes presented to it, but was of opinion that the Howell torpedo (Plate 21) alone appeared to justify an expenditure for further experiment. Abroad, the Whitehead torpedo (Plate 8) is a commercial success. It has been adopted by all the leading nations except the United States.

Concerning another class of torpedoes, "fixed," or "anchored," or "planted," technically known as submarine mines, there is a great popular misapprehension. Their value is greatly overestimated. Their limitations and indispensable auxiliaries are set forth by Lieut. Col. H. L. Abbot, of the Engineer Corps. (Appendix, p. 145.) They require picked and trained men for their management, electrical apparatus for their discharge and for lighting up the approaches, stations on shore secure against sudden assault, a flanking fire of canister and case shot, and of machine guns (themselves protected), light-draught picket-boats, and the overshadowing protection of armored forts and heavy guns. None of these things can be extemporized. The submarine mine alone is of little use, and it must accompany, not precede more costly and less easily prepared means of defense.

THE LATEST TYPES OF SHIPS AND THEIR ARMAMENT.

To assist in a proper understanding of the problem of building ships and providing them, as well as sea-coast defenses, with proper armament, your committee has collected and presented in the Appendix illustrations and descriptions of the latest type of barbette (Plate 6) and turret (Plate 7) ships, protected cruisers (Plate 10), and sea-going torpedo-boats (Plates 24, 25, and 26); the gun-carriages and shields (Plate 2) largely adopted in Europe; the heaviest forged steel shafting, that for the City of Rome (Plate 11), and that for the side-wheel steamer Ireland (Plate 12), which has been manufactured, and the most powerful gun (Plate 13) yet finished; rapid-firing guns (Plates 4 and 5) for the armament of dispatch and torpedo boats, and the secondary batteries of other vessels; the most efficient torpedoes (Plates 8 and 21), with their guns (Plates 8 and 9) and launching apparatus (Plate 23); and the most advanced experiment in submarine artillery (Plate 27). The illustrations are published by permission obtained, in most cases, from foreign authorities; in other cases, from American authors who have been authorized to make them public.

BEST METHODS OF MANUFACTURING GUNS AND ARMOR.

We have already indicated the best methods of building engines and ships. There are three ways of building heavy guns and forging armor. One is in works built and conducted by the Government; the second, in works subsidized by Government loans—a virtual partnership; the third is partly by the Government works and partly by private persons.

Our report and Appendix show the nature of the task of building guns. To completely make the modern weapons would require of any of our largest steel-makers, some of whom have open-hearth furnaces large enough, or nearly so, for the heaviest castings, an additional investment of not less than two millions. Probably a responsible and able establishment, if it were induced by long and large contracts, would invest more than that in order to conduct its work to its own entire satisfaction. It is not probable that Congress will be disposed to offer contracts that would justify private works in making so large an expenditure.

Were the Government to undertake the full manufacture, its necessary additional plant would cost fully as much, probably considerably more. Its officers are not trained in the practical work of making the steel or forging it in great masses.

The experiment of a Government advance of money for the plant to private parties, and conducting the work by a virtual partnership, has been tried by Russia and England. In the former country the Government bought up nearly all the private shares, and the manufactory has practically become Government property. In England, after paying high prices for several years to the Elswick Ordnance Company, the Government paid $325,000 to be relieved from its obligations, and the concern has been absorbed into the great establishment of Sir William G. Armstrong, Mitchell & Co. (limited), at Newcastle-on-Tyne. It is not likely the experiment will be repeated.

But it is entirely practicable to divide the work. Men of large experience in steel-making, and commanding abundant capital, are ready to undertake to cast, forge, and deliver to the Government the rough parts of steel guns, adopting the best known processes of producing the suitable steel, proved at every step by severe tests, and forged by the hydraulic process. The additional plant for this share of the work would cost nearly a million. The remaining work of fine boring, turning, and fitting is machine work that requires skill certainly, but it can be well done in Government shops under the supervision of our own officers.

The preliminary heavy investments would thus be divided nearly equally. There would be but half the risk to the private maker, and the number of firms or corporations eager to bid would be largely increased. In the course of a few years it is quite certain that the private makers would be disposed to enlarge their works and build the complete gun, when the Government could either dispose of its plant or hold it in reserve as a powerful check or for experimental work.

The private citizens who have conferred with us and the other boards and commissions submit some considerations which we approve. They invite constant, intelligent, sensible, and sharp inspection, and the closest tests of steel at every step. They all concur in saying that they desire payments only upon the delivery of their products fairly adjudged to be thoroughly up to the requirements. They further say whoever is charged with awarding contracts should not be required to award to the lowest bidder, should consider only proposals coming from men of great experience and abundant capital, and should be at liberty to reject any and all proposals. Somebody must be trusted with power and discretion and held to the resulting responsibility.

The manufacture of armor must be intrusted wholly to private persons. It can best be finished where it is forged.

Your committee was inclined to say that one Government finishing shop or "gun factory" should be sufficient at the beginning, but if our

coast defenses are to be put into the condition demanded by the present state of the arts of warfare they must be substantially entirely renewed, and our new Navy must be in like manner almost wholly a new creation. The task is not a light one.

Our present national resources are such that the burden of doing what the best military science and judgment recommend is far less proportionately than what the country freely did when its coast defenses and its Navy and their armament were among the very best in the world. We believe that in order to produce guns with a reasonable degree of rapidity two Government gun factories would be profitably employed, and would be absolutely needed.

The Gun Foundry Board says:

Approximate cost of plant for producing the tempered parts of guns up to 100 tons, ready for delivery at gun factories.

Casting	$250,000
Forging (hydraulic press)	150,000
Rough boring and turning	210,000
Tempering	50,000
	660,000
Additional cost if liquid compression be adopted	175,000
Total	*835,000

Approximate cost of plant for each gun factory.

Guns up to 6-inch caliber	$50,000
Guns from 6-inch to 12-inch caliber	150,000
Guns from 12-inch to 16-inch caliber	350,000
Buildings and shrinking pit	350,000
Total	*900,000

* Based upon estimates abroad and do not include ocean freight and customs dues.

LOCATIONS.

The best locations for the gun factories are the Washington navy-yard and the Watervliet Arsenal. The former has already a plant that has been employed in the finishing work upon twenty-one modern steel guns, of calibers ranging from 5 to 10½ inches, most of which are finished. The site is naturally secure from an attack by a foreign fleet.

The Watervliet Arsenal has 109 acres of ground, with 1,600 feet of water front. Both locations have excellent railroad and water communications with the regions likely to supply the rough material and with the places where the products will be needed. Both are away from the disturbing influences of great centers of population, and each has a salubrious climate. Each place is easily defensible against a foreign enemy.

For valuable evidence and arguments relating to the matters just discussed we refer especially to our extracts from the report of the Gun Foundry Board, and the statements submitted by able men of such representative establishments as the Otis Iron and Steel Company, the Cambria Iron Company, the Pennsylvania Steel Company, the Bethlehem Iron Company, the Midvale Steel Company, and, indeed, to the concurrent testimony of all whom we have consulted.

We also commend to careful attention the full and very valuable report of the Fortifications Board just submitted by the Secretary of War.

The policy indicated was fully approved by President Arthur and Secretaries Lincoln and Chandler.

We are well assured that at least forty millions of capital is ready to be placed at the service of the Government upon terms that would be approved by wise and capable men in private transactions.

CONCLUSIONS.

Our conclusions are:

(1) The United States is metallurgically independent for all purposes of warfare.

(2) The manufacture of iron and steel for peaceful purposes has kept pace with the foremost science and skill of the world. For steel-making, the casting capacity is ample, but the heavy forging and finishing of guns and armor will require new and costly plants.

(3) The machinery and machine-tools of the navy-yards are sufficient for the building of engines, but much of it is obsolete and no longer economical; the means of building iron or steel ships are lacking; one yard has a good plant of limited capacity for finishing steel guns, and has done some good work.

(4) As a partial check upon private builders and as a resource in case of necessity, some ships should be built in navy-yards, the parts to be furnished by private foundries. Ships in general should be built by private contract, and private yards are capable of doing the work. The uncertain nature of repairs is such that some Government yards should be kept ready to make them.

(5) Armor plate and engines should be obtained wholly from private manufacturers.

(6) The costly experiments of twenty-five years have reached a stage which justifies certain conclusions. Guns should be made of open-hearth steel, forged, breech-loading, chambered, of calibers ranging from 5 to 16 inches, of lengths ranging from 30 to 35 calibers. Armor and projectiles should be made of forged steel. The hydraulic forging press produces better results than the steam-hammer, costs much less, and should be used for government work. Ships should be constructed of steel, but certain minor classes may be composite of steel and wood.

(7) The manufacture of guns suitable for ships and coast defense should be divided between private foundries and Government shops; the former providing the forged and tempered parts, and the latter finishing those parts and assembling them.

(8) The Government should establish two factories for machine-finishing and assembling guns. The weight of opinion among Army and Navy experts and prominent manufacturers of heavy work in steel decidedly indicates the Washington navy-yard and the Watervliet Arsenal as the best sites for such factories. When the determination to contract for heavy guns shall have been reached, the localities for finishing them can easily be determined.

(9) All needed private capital is ready for cheerful coöperation with the Government in whatever it may require.

(10) Proposals for armor and guns should require such quantities and extend over such a series of years as to justify private persons in securing the best plant. Payments should be made only for completed work and only the guaranteed bids of persons having capital and experience should be considered.

Respectfully submitted.

J. R. HAWLEY, *Chairman.*
N. W. ALDRICH.
W. J. SEWELL.
J. T. MORGAN.
M. C. BUTLER.

APPENDIX.

BOOKS FOR REFERENCE.

ORDNANCE AND WAR SHIPS.

Transactions of the American Institute of Mining Engineers. R. W. Raymond, Ph. D., secretary. New York. 1881–'83. Illustrated.

Valuable papers on metallurgy; methods of manufacture; furnaces; management and treatment of steel; distribution of ores, &c.

Construction of Vessels of War for the Navy. Hon. B. W. Harris, M. C., chairman Committee on Naval Affairs. House Report No. 653. 1882.

Views and opinions of certain officers of the Navy, manufacturers of iron and steel, and shipbuilders of the country as to the best mode of constructing vessels of war, and the character of material and armaments best fitted for that purpose, submitted before the Committee on Naval Affairs, in obedience to an order passed by the House of Representatives February 8, 1882.

Report of the Chief of Bureau of Army Ordnance. Brig. Gen. S. V. Benét, U. S. Army, Chief of Ordnance. Public document. 1882. Illustrated.

Reports of the Getty Board; on European ordnance and manufactures, by Col. S. Crispin, U. S. Army; of the Ordnance Board on various trials of guns and projectiles.

Report of the Getty Board on Heavy Ordnance and Projectiles. Bvt. Maj. Gen. George W. Getty, president. Senate Ex. Doc. No. 178, 47th Congress, 1st session. 1882. Illustrated.

Report of Board appointed in conformity with the act of Congress approved March 3, 1881, for the purpose of making examinations of all inventions and improvements of heavy ordnance and projectiles; detailed report of examinations, and recommendations as to what inventions are worthy of actual test and the estimated cost of such tests; Lyman-Haskell multicharge gun; composite (iron and steel) guns; Woodbridge and Army Ordnance wire-guns; detailed report of the bursting of Woodbridge gun, and recommendations of Board.

Senate Ordnance Report. Senator John A. Logan, chairman. Senate Report No. 969, 47th Congress, 2d session. 1883. Illustrated.

Report of the Select Committee on Heavy Ordnance and Projectiles; views and submitted plans, designs and estimates of inventors and manufacturers of cannon and projectiles and of the Chief of Army Ordnance; experimental guns recommended; statements of W. E. Woodbridge, W. W. Hubbell, H. F. Mann, Col. T. Yates, J. R. Haskell, Gen. S. V. Benét, W. P. Hunt, C. Plagge, A. H. Emery, and Norman Wiard.

Report of the Secretary of the Navy. Public document. 1883. Illustrated.

Reports on armored vessels, steel cruisers, marine rams, torpedo-boats, proposed additional vessels, types of guns.

Report of the Chief of Bureau of Army Ordnance. Brig. Gen. S. V. Benét, U. S. Army, Chief of Ordnance. Public document. 1883. Illustrated.

Reports of the Ordnance Board on trials of various guns and carriages; description of the U. S. testing-machine at the Watertown Arsenal; experimental guns being fabricated under contract; shrinkage tests of steel hoops, and mechanical tests of specimens taken from them.

Metallurgy of Iron. By First Lieut. Constantine Chase, Third Artillery, U. S. Army. Ordnance Notes, No. 324. 1883. Illustrated.

Historical sketch; distinctive characteristics, physical and chemical properties, manufacture and treatment of malleable iron, steel, and cast-iron; description of furnaces and processes.

The Development of Armor for Naval Use. By Lieut. E. W. Very, U. S. Navy. Annapolis, Md.; U. S. Naval Institute. 1883. Illustrated. $1.

A comprehensive history of the development of armor; projectile energy and armor resistance; iron armor and smooth-bore guns in Europe and the United States; iron armor and rifled guns; steel and compound armor; inclined armor; Gruson chilled armor; armor manufacture and laws of penetration.

Our New Cruisers. By Assistant Naval Constructor Francis T. Bowles, U. S. Navy. Annapolis, Md.; U. S. Naval Institute. 1883. Illustrated. $1.

General description of cruisers Chicago, Boston, Atlanta, and dispatch-boat Dolphin as designed and contracted for; dimensions, batteries, details of construction of hulls and machinery; general internal arrangements; tests of mild steel for cruisers; table of war-ships building throughout the world at the date of issue.

The Heavy Guns of 1884. By Col. E. Maitland, R. A., Superintendent Royal Gun Factory, Woolwich, England. London; Journal of the Royal United Service Institution, No. 126. 1884. Illustrated.

Improvement in powder, mechanical appliances, and the production of large masses of steel are the chief causes that have led to re-armament; powder development; breech-loading; relative excellence of latest types of heavy guns in Europe; comparative table of powers of B. L. guns of 1881–1884.

The Construction of Additional Steel Vessels for the Navy. Senate Report No. 161, 48th Congress, 1st session. 1884.

Report of the committee; extracts from reports of Secretary of the Navy and Naval Advisory Boards; additional new vessels proposed; rams; torpedo-boats; list of available vessels; date of construction, original cost, and total expense for repairs of vessels borne on register November, 1883; views submitted to the committee; paper on the Navy of 1884, by Lieut.-Commander F. M. Barber, United States Navy; ships of war building, 1883–'84; letter of Chief Engineer B. F. Isherwood, United States Navy, to Senator Hale; reply of the Naval Advisory Board to the same.

Report of the Secretary of the Navy. Public document. 1884. Illustrated.

Contains reports on new cruisers, additional vessels, completion of monitors, torpedo-boats for coast defense, Gun-Foundry Board, Navy-Yard Commission, Torpedo Board, work of the Naval Bureau of Ordnance, experiments with projectiles and gun-cotton.

Sea-Coast Defenses.—Extract from the Annual Report of the Chief of Engineers, U. S. Army. Public document. 1884.

Review of modern requirements for defense of our sea-coast cities; Contributions; submarine mines; torpedoes; sea-coast and lake frontier defenses; estimates of appropriations; boards of Engineers; summary of their operations.

Report of Gun-Foundry Board with Supplement. Rear Admiral E. Simpson, president. House Ex. Doc. No. 97, 48th Congress, 1st session, February, 1884. Supplementary Report, December, 1884. Illustrated.

Sources in England, France, Germany, Russia, and the United States from which armaments are supplied; condition of steel manufacture; present condition of artillery; cost of plant for the manufacture of guns; sites selected and plans for gun factories and their cost; conclusions and recommendations of the Board.

Report of the Commission on Navy-Yards. Commodore S. B. Luce, U. S. Navy, president. Senate Ex. Doc. No. 55, 48th Congress, 1st session. 1884. Illustrated.

Reports condition and uses of yards and plants; advantages and disadvantages of sites; plans of yards and stations; tabulated statements showing character, value, and condition of the improvements; value of machinery and personal property; area, cost of site, and improvements; present value of site, improvements, machinery, and personal property; and cost of maintaining the various yards, with value of their products during each of the past fifteen years to June 30, 1882; conclusions and recommendations.

Report of Armament Board. Colonel T. G. Baylor, Ordnance Corps, U. S. Army, president. Senate Ex. Doc. No. 5, 48th Congress, 2d session. 1884.

Appointed in pursuance of act of Congress approved July 5, 1884, to determine the various calibers, lengths of bore, greatest and least admissible weights of guns for each caliber, weights of projectiles for each, together with the number of each caliber of gun required.

Iron Ores. By A. A. Blair, chief chemist. Public Document. Tenth Census. Mines and Mining Industries. 1884.

Chemical analyses of average commercial samples of all the important iron-ore deposits of the United States; samples taken 1879–1881; methods employed in the analysis of iron ores.

Directory of the Iron and Steel Works of the United States. Published by the American Iron and Steel Association. Philadelphia. 1884.

Includes names and descriptions of all the iron and steel works of the United States, embracing blast-furnaces, rolling-mills, steel works, forges, and bloomaries, in every State and Territory.

Iron in All Ages. By James M. Swank, vice-president of the American Iron and Steel Association. Philadelphia; published by the author: 261 South Fourth street. 1884. $5.

History of the manufacture of iron and steel in all ages, and particularly in the United States, for 300 years, from 1585 to 1885.

The Establishment of Steel Gun Factories in the United States. By Lieut. W. H. Jaques, U. S. Navy. Annapolis, Md.; United States Naval Institute. 1884. Illustrated. $2.50.

A presentation of the views of Congress, committees, chiefs of Departments, and experts on the subject of the proper means of defense and the preparation for it; an amplification of the report and conclusions of the Gun Foundry Board; a convenient reference, profusely illustrated and indexed, to the details of the manufacture of ordnance and armor; descriptions of some of the largest steel works and ordnance factories of the world; types of weapons; detailed estimates of cost of plant and time of production.

Mild Steel applied to Naval and Military Purposes. By Maj. G. Mackinlay, R. A. London; Royal United Service Institution. Jan. 30, 1885. Illustrated.

Annual production of iron and steel in 1882 for each country; processes of manufacture; forging; tempering; steel castings; tests; steel for ordnance; Whitworth's hydraulic forging-press; gun carriages; projectiles; armor; and parts for ship construction.

Capabilities of Private Firms to manufacture Heavy Ordnance for the British Service. By W. Anderson, esq., C. E. London; Journal of the Royal United Service Institution, No. 129 (extra number). 1885.

Sketch of the development of material of war; capacity of present works to manufacture material and fabricate guns; best means to secure rapidly a supply of heavy guns lies in the method of obtaining the parts from the private manufacturers, and finishing them at the Royal Arsenal, and establishing a second gun factory; English development of war material suffering from the cry of economy.

Questions Maritimes. By Émile Weyl, lieutenant, French Navy. Paris; Berger-Levrault et Cie. 1885.

Valuable sketch of the questions of naval construction, ordnance, armor, and torpedoes in France, with papers on naval warfare, armor, guns, recent experiments, and recommendations.

Report on Heavy Ordnance. Hon. William S. Rosecrans, M. C., chairman. House report No. 2546, 48th Congress, 2d session. 1885.

Statements of Norman Wiard Gen. S. V. Benét, and James R. Haskell. Conclusions and recommendations and framed bill.

Report of the Naval Advisory Board on Mild Steel for New Cruisers. Prepared by Assistant Naval Constructor R. Gatewood, U. S. Navy. Report of the Secretary of the Navy. Public document. 1885.

Use of mild steel in construction of vessels; requirements of Navy Department; inspection and tests, chemical requirements and methods of analysis; Admiralty, Lloyds', French, Liverpool Underwriters', and Bureau Veritas' requirements for steel.

Mineral Resources of the United States for the calendar years 1883–1884. By Albert Williams, jr., chief of Division of Mining Statistics and Technology. Public document. United States Geological Survey. 1885.

Statistical report upon the present condition of the mining industries of the United States, production, imports, and exports; coal; petroleum; manufacture of coke; natural gas; iron; manganese; chromium; and other minerals.

The Present Technical Condition of the Steel Industry in the United States. By Phineas Barnes. Public document. Bulletin of the United States Geological Survey, No. 25. 1885.

Supplementary to the report of the "Mineral Resources of the United States, 1883–'84," giving a general view of existing conditions and practice; raw materials, processes, machinery, and products.

Information from Abroad. General Series No. IV. Public document. Office of Naval Intelligence, Bureau of Navigation, Navy Department. 1885.

Descriptions of the latest types of ships recently built and building in or for England, France, Italy, Germany, Russia, Brazil, Chili, and Japan; ordnance development in the United States, England, France, and Germany; and the progress in torpedo and torpedo-boat development.

The Hotchkiss Revolving Cannon. By Lieut. E. W. Very, U. S. Navy. Paris. For private circulation. 1885. Illustrated.

Description and illustrations of the systems as designed for naval service, field artillery, and flank defense, together with firing tables, proving-ground tests, and official reports of Gâvre, Shoeburyness, Sandy-Hook, Pola, Spezia, Helder, Copenhagen, St. Petersburg, and Portsmouth.

Heavy Ordnance for National Defense. By Lieut. W. H. Jaques, U. S. Navy, New York and London. G. P. Putnam's Sons. 1885. Illustrated. 25 cents.

A consideration of the present defenseless condition of the coast cities of the United States and of the necessity for the immediate production of heavy guns adapted to modern warfare, together with suggestions concerning the best type to accept, and the most advantageous system of construction.

Our Sea-Coast Defenses. By Lieut. Eugene Griffen, U. S. Army. New York and London. G. P. Putnam's Sons. 1885. 25 cents.

A description of our sea-coast defenses, past and present; tables of modern heavy ordnance; appropriations for fortifications since 1866; value of destructible property exposed to an enemy; proposed harbor defenses; extreme ranges of modern heavy ordnance; use of armor; and list of foreign armored ships available for offensive operations against the United States.

Ericsson's Destroyer and Submarine Gun. By Lieut. W. H. Jaques, U. S. Navy. New York and London. G. P. Putnam's Sons. 1885. Illustrated. 50 cents.

A consideration of their application to naval warfare, the advantages of the system, together with a short history of submarine artillery.

Ships of War. By Assist. Naval Constructor Francis T. Bowles, U. S. Navy. New York. A. J. Johnson & Co. 1885. Illustrated.

Historical sketch of recent naval construction in the United States, England, and France; descriptions of typical modern war ships of various classes; brief reviews of armor, guns, materials of construction, machinery, and torpedoes, together with tables of the armored and unarmored vessels of the world.

Reconstruction and Increase of the Navy. By Ensign W. I. Chambers, U. S. Navy. Annapolis, Md.; U. S. Naval Institute. 1885. Illustrated. $1.

Duties of a navy; types of ships required; comparison of late high-power guns and a graphic comparison of their power and accuracy; building programme; navy-yards and naval stations; organization of departments.

Report of the Fortifications Board, Hon. Wm. C. Endicott, Secretary of War, President. Senate Ex. Doc. No. 43, 49th Congress, 1st session, 1886. Illustrated.

Appointed under act of Congress of March 3, 1885, to "examine and report at what ports fortifications or other defenses are most urgently required, the character and kind of defenses best adapted for each, with reference to armaments," and "the utilization of torpedoes, mines, or other defensive appliances." Selects eleven points at which the best modern defenses are "urgently required," and specifies for such defense: 110-ton breech-loading rifled cannon, 14-inch, 12-inch, and 10-inch breech-loading rifles, 12-inch rifled mortars, turrets, armored casemates and barbettes, floating batteries, fixed and movable torpedoes; recommends 150 torpedo-boats and rapid-firing and machine guns; discards iron and multi-charge guns; comparison of iron and steel guns; list of ports, with description of fortifications and other defenses, with reference to armament, mines, torpedoes, etc.; guns on hand; estimates for land defenses exclusive of armament; armament and mountings, floating batteries and their armament, submarine mines and their adjuncts, and torpedo boats; practical measures for obtaining the appliances for defense; indorses conclusions and estimates of Gun Foundry Board, and recommends "that the steel manufacturers should be called upon to provide the material," and the guns fabricated in two gun factories, one for the Army and one for the Navy; appropriations recommended. The whole subject, with estimates, is discussed in detail, and the conclusions and recommendations of the Gun Foundry Board are cited and indorsed.

The Navy and its Prospects of Rehabilitation. By Rear Admiral Edward Simpson, U. S. Navy, President, U. S. Naval Institute. Annapolis, Md.; Naval Institute. 1886. $1.

What has been done for a new navy; armored coast defense, and training vessels; guns, gun foundries, and gun factories; armor; torpedoes; engines and boilers; hydrographic work; U. S. Naval Academy; and tribute to the Hon. George Bancroft.

Modern Armor for National Defense. By Lieut. W. H. Jaques, U. S. Navy. New York and London. G. P. Putnam's Sons. 1886. Illustrated. 50 cents.

Presents practical information about material, methods of manufacture, cost, development, tests, and application, effects of fire, resistance of plates, and a comparison of the results that have been obtained at the most important competitive trials, together with statistics.

The following reports have been presented to Congress, but no order for printing them has been made at the date of this report:

Report on European Sea-coast Fortifications. By Capt. W. H. Bixby, U. S. Engineers.

Report of a visit to Belgium, Holland, Germany, Italy, and England in 1881-'82, and presentation of information relating to turrets, ordnance material, sea-coast fortifications, and armor material, principally Gruson.

Report on European Dockyards. By Naval Constructor Philip Hichborn, U. S. Navy.

European dockyards; details fitting, and equipment of foreign vessels, torpedo-boats, ship-yard appliances and tools.

REPORT

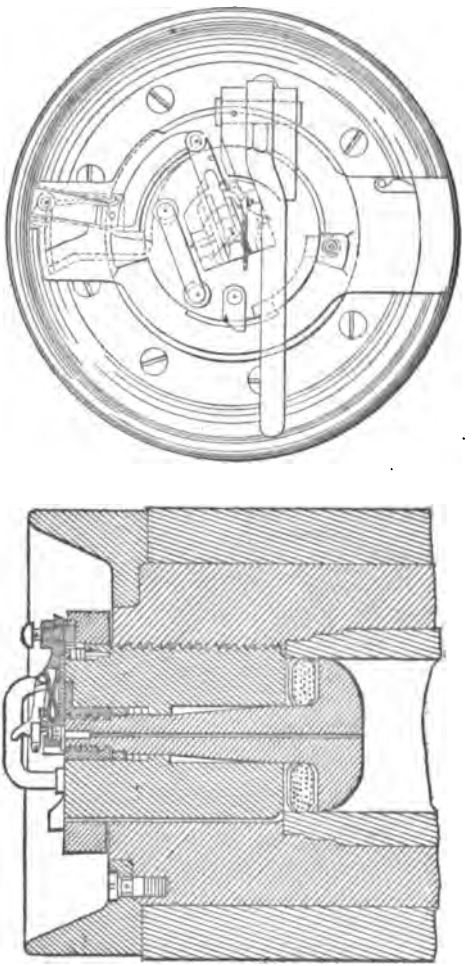
OF

SUBCOMMITTEE ON ORDNANCE AND WAR SHIPS

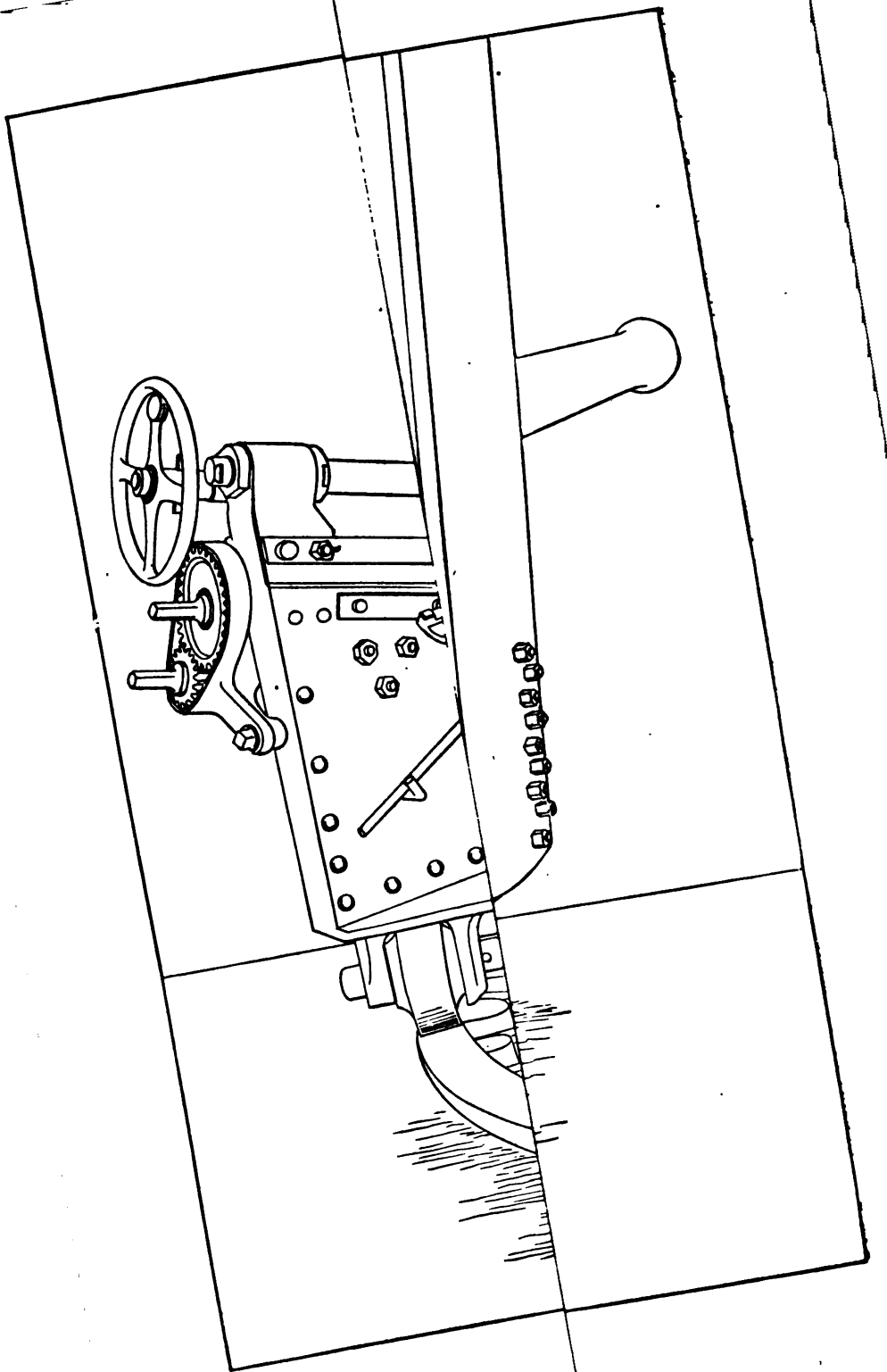
RESPECTING A

VISIT TO SOME OF THE LEADING DOCK-YARDS AND PRIVATE SHIP-BUILDING AND ORDNANCE ESTABLISHMENTS IN ENGLAND, AUGUST, 1885.

Plate 1.



Royal Gun Factory (Woolwich), Breech Action.



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REPORT OF SUBCOMMITTEE ON VISIT TO ENGLAND.

The members of the subcommittee availed themselves of their presence in Europe to visit some of the dock-yards and private establishments in England where war vessels of different types are building and ordnance material of every description is manufactured. We were accompanied by Commander F. E. Chadwick, U. S. N., naval attaché to the legation of the United States, London, and Lieut. W. H. Jaques, U. S. N., and were everywhere received with marked attention and courtesy.

ROYAL ARSENAL, WOOLWICH.

At the Woolwich Royal Arsenal several thousand men are employed and many acres are covered with shops in operation. The departments were visited, and the operations in their various stages were described by the officers in charge. Lieutenant Wingfield, R. N., greatly assisted the investigations of the committee by his explanations. Among a multitude of other products were projectiles for 100-ton guns; carriages of all sizes, from the field to the proof carriage for the new 110-ton breech-loading rifle; Woolwich fish torpedoes (Whitehead system) and their guns, and steel breech-loading rifled guns up to and including that of 66-tons' weight in the lathes and being sighted.

The 250-ton steam crane was operated to show with what ease it could be handled when required for use over the shrinkage and tempering pits. Very many additions are being made to the already very large gun factories and very powerful lathes are being set up. The trepanning (boring around a core) plant here is probably the most efficient in the world. A 9.2-inch wire gun was approaching completion, the flat wire being very effectively wound with a simple machine.

The Woolwich authorities claim that the steel plant employed for experimental work is a most excellent check upon the steel-makers who are supplying the material. It is stated that the effect has been to reduce the price and raise the quality of the steel.

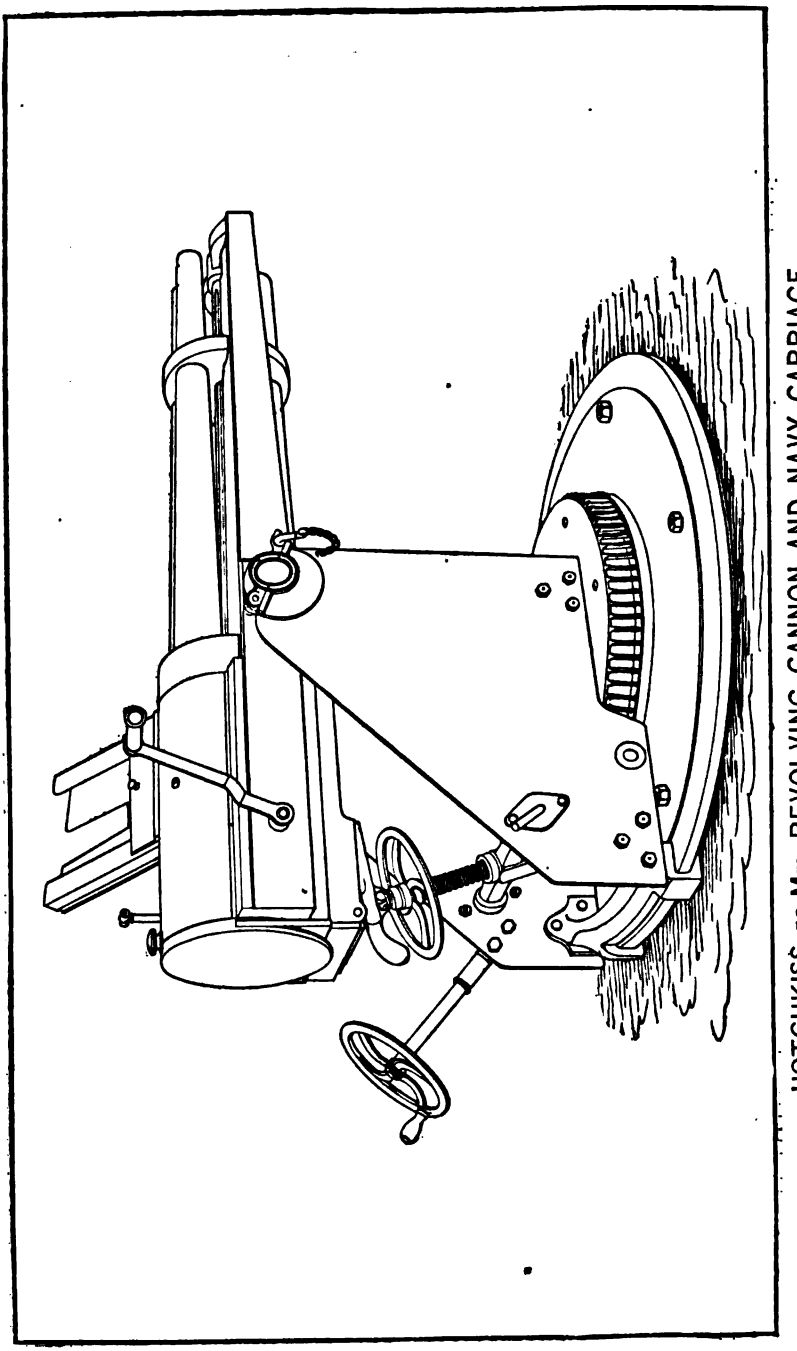
VAVASSEUR GUN MOUNTINGS.

A large number of Vavasseur hydraulic gun mountings were being inspected and proved, together with the Woolwich carriages of similar system. Plate 1 shows the breech-closing mechanism employed at Woolwich. Plate 2 represents a Vavasseur center-pivot carriage and shield. Its advantages are applicability, simplicity, and the limited space occupied. Eight hundred of these mountings have been manufactured for various powers, principally England, France, and Spain, and Germany is now negotiating for their manufacture or supply.

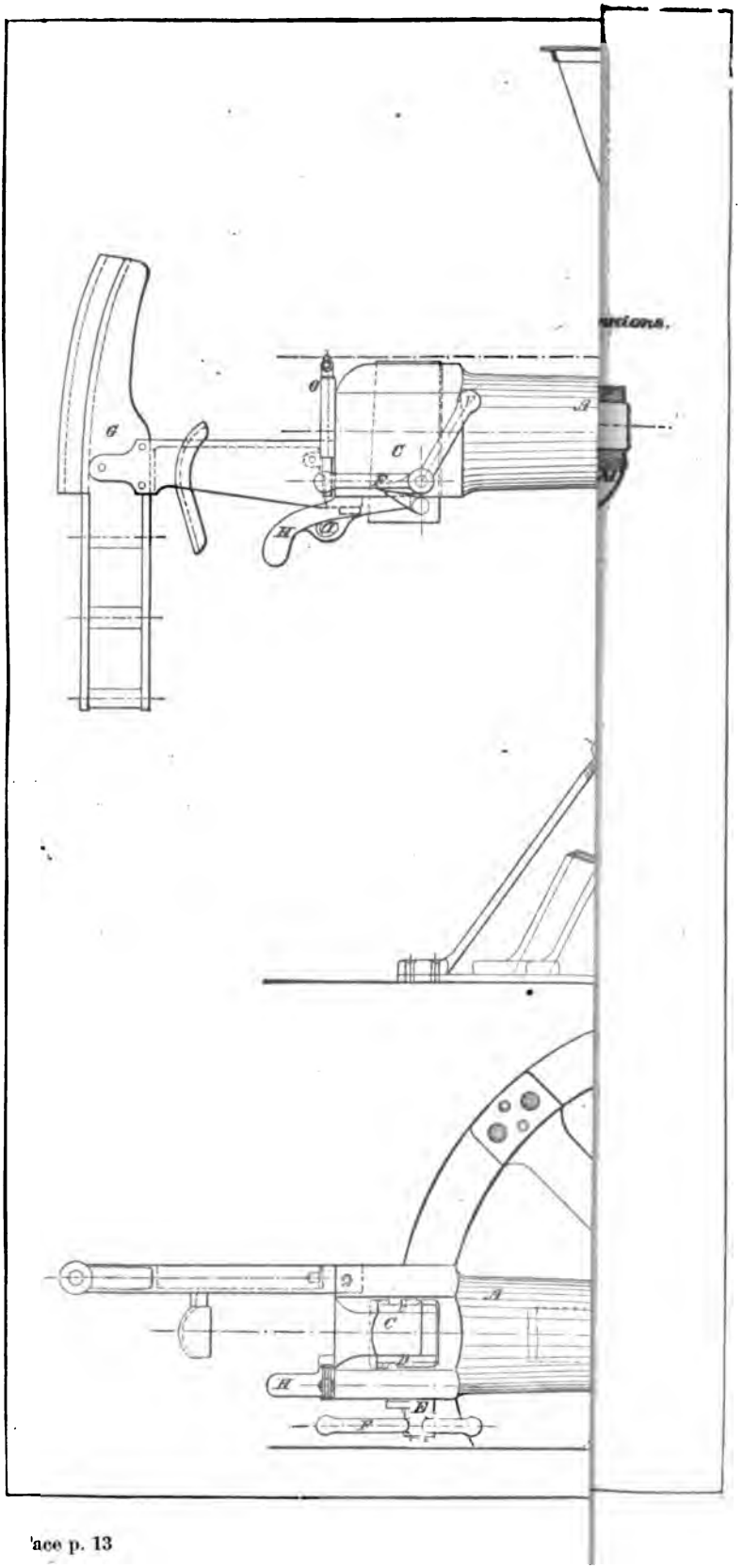
RAPID-FIRING GUNS.

Hotchkiss and Nordenfelt rapid-firing guns were also being prepared for service. Authorities differ as to which is the superior weapon, but all concur in the opinion of the necessity for a large number of this type

Plate 3.



HOTCHKISS 53 Mm. REVOLVING CANNON AND NAVY CARRIAGE.



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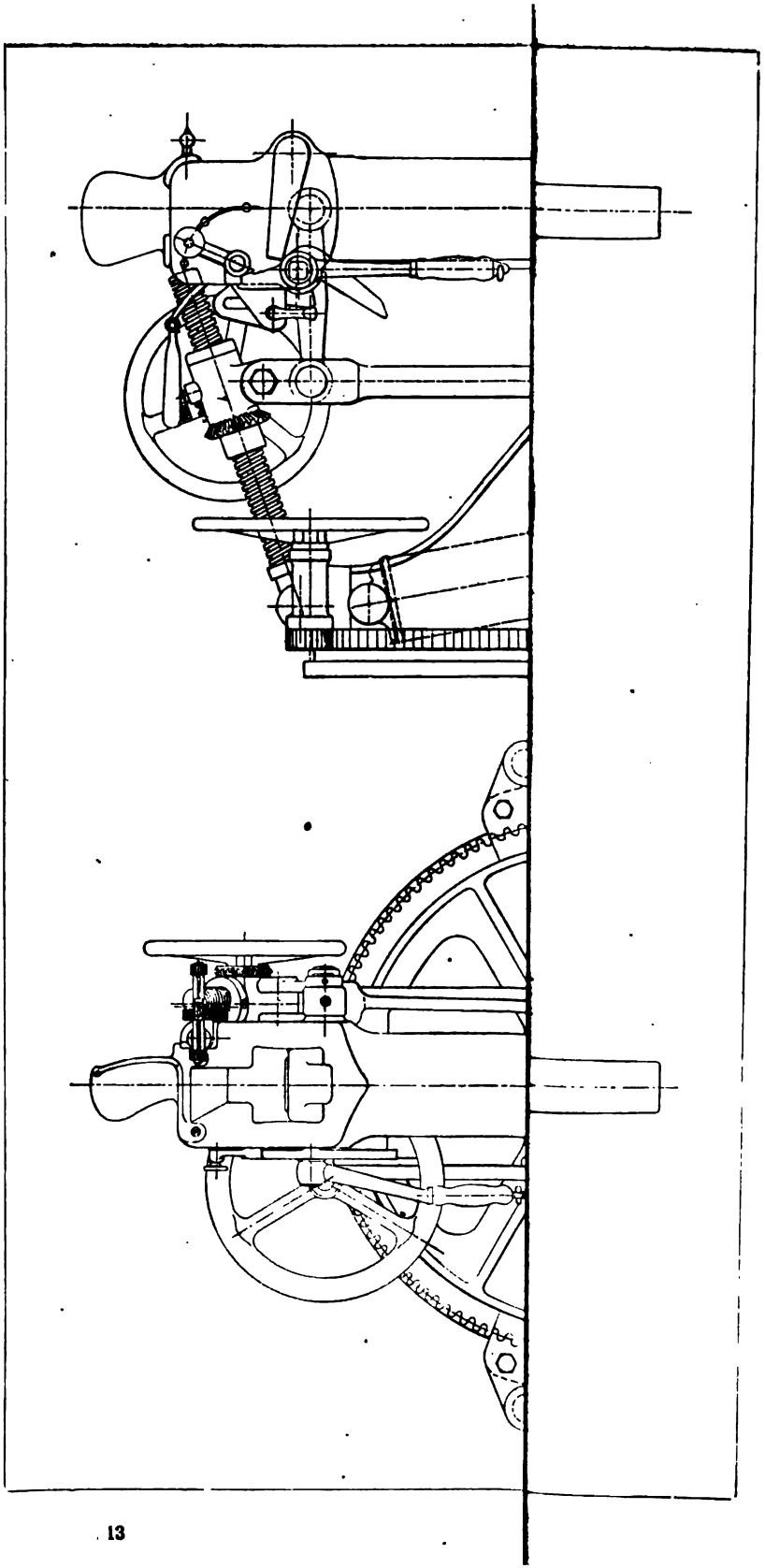


for the armament of torpedo and dispatch boats and the secondary batteries of other vessels of war. Plate 4 contains an elevation, plan, and section through the trunnions of a Hotchkiss 57-millimeter (2.24 inches) 6-pounder rapid-firing gun.* Plate 3 is a Hotchkiss 53-millimeter (2.09 inches) revolving-cannon and Navy carriage, designed for defensive service against torpedo-boats and effective offensive service against open-deck batteries, or in boat and naval brigade work. Plate 5 contains an elevation and plan of the Nordenfelt 6-pounder (2.25 inches) rapid-firing gun and recoil carriage. Maximum rapidity of fire 30 rounds per minute; with deliberate aim 12 rounds; penetration of solid wrought-iron 5.39 inches.

PROVING GROUND, SHOEBURYNESS.

At Shoeburyness the committee inspected a large number of targets of English compound armor (wrought-iron and steel) in various conditions of demolition, and were impressed with the extensive scale on which these experiments are conducted; but it is to be regretted that England has not extended this valuable work to include comparative work with different characters of armor-plate. Recent experiments have been made against targets erected to represent as nearly as possible sections of the Spithead forts and Her Majesty's armored barbette ship Rodney (9,700 tons). The results showed the superiority of the gun over these targets of English compound armor.

The range at Shoeburyness and all the appliances are very extensive, and the great rise and fall of the tide assist greatly to a successful conduct of the tests and the recovery of the projectiles.

CHATHAM DOCK-YARD.

At the Chatham dock-yard from 10,000 to 12,000 men are at present employed, and in addition to the ordinary repairs and refits going on and the care of a large number of war ships of various types, the following were laid down in different stages of construction:

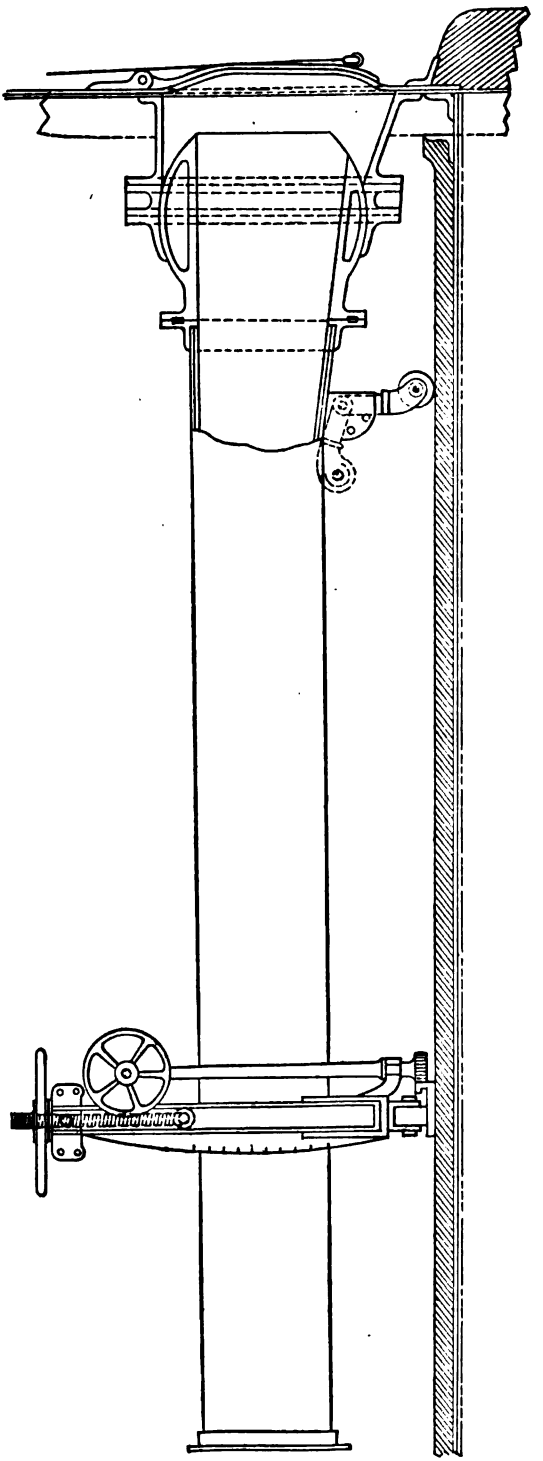
Name.	Type.	Displacement.	Indicated horse-power.
		Tons.	
Rodney*	Armored barbette ship	9,700	9,500
Warspite*	do	7,390	8,000
Hero*	Armored turret ship	6,200	6,000
Severn*	Protected cruiser	8,550	6,000
Mersey*	do	8,550	6,000
Calypso*	Partially protected corvette	2,770	3,000

* For description see page 103.

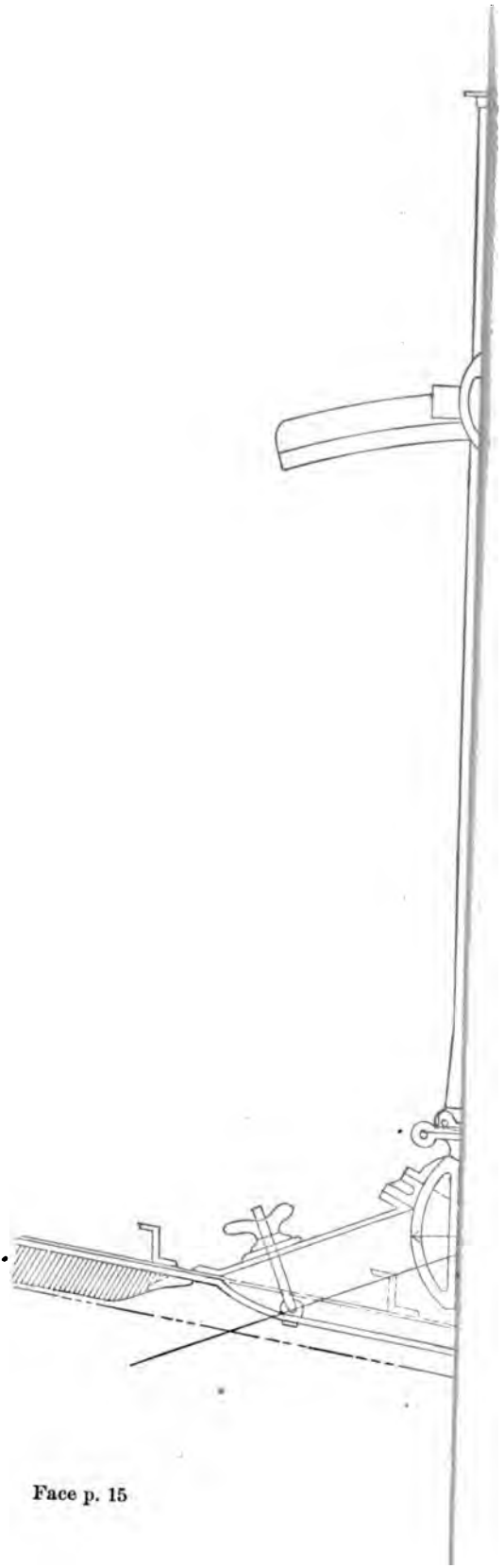
Plates 6 and 7 represent in detail the principal features of the modern English barbette and turret types. The Camperdown† is building at Portsmouth. The Agamemnon was launched in 1879, and is armed with four 12½-inch and two 6-inch breech-loading rifles. Her maximum speed is 13 knots, with an indicated horse-power of 6,360. Her Majesty's turret ship Conqueror (sister ship to the Hero‡) having

* For description see page 444.
† For description see page 110.
‡ For description see page 114.

Plate 8.



Whitehead Torpedo and Gun.



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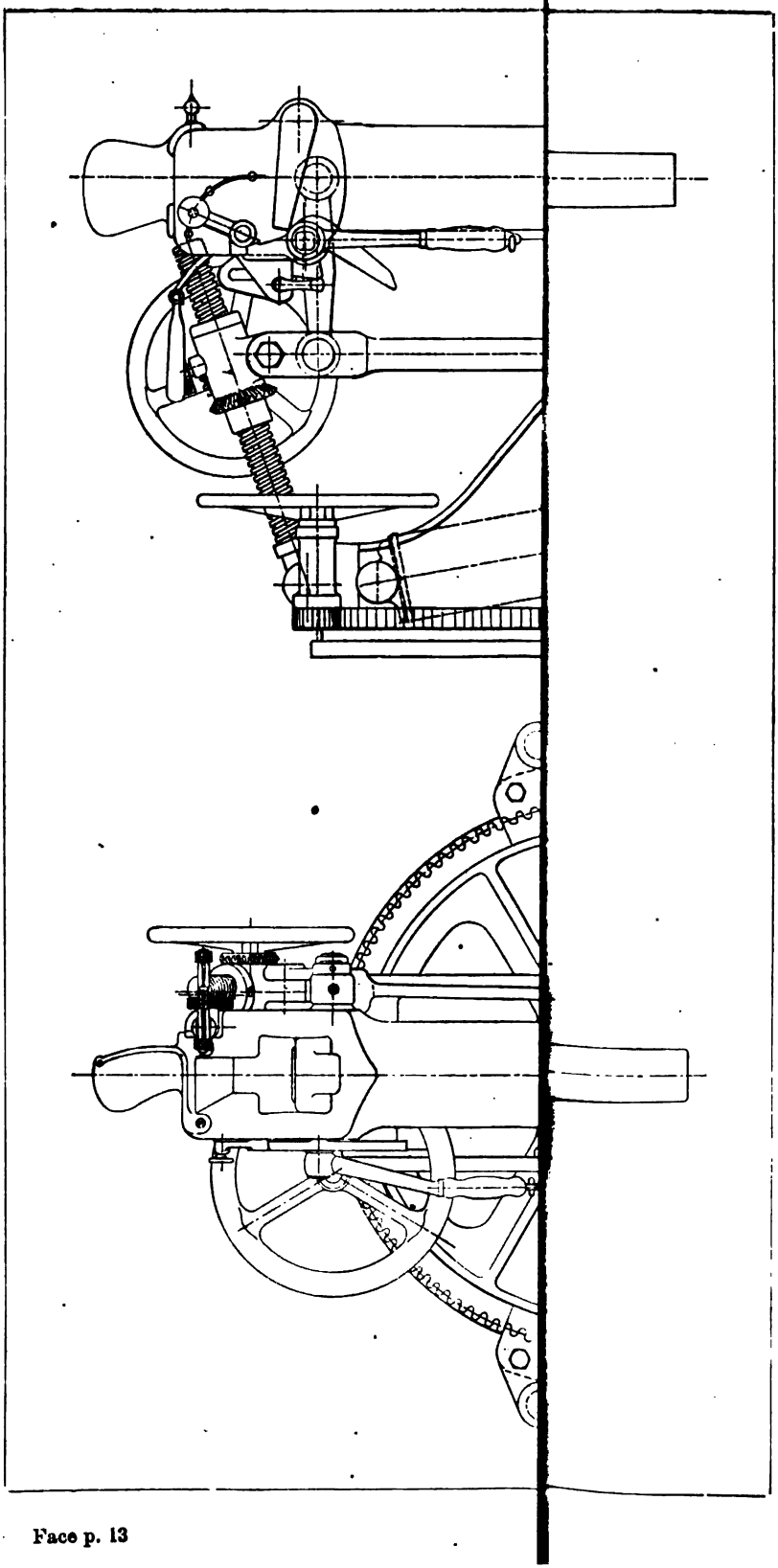

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The majority of these manufacturers, as well as the Elswick Company, are making costly additions to their already capacious works, expending millions of pounds sterling to put themselves in a position to supply the quantities and masses of steel now required by the British Government.

Thomas Firth & Sons are considering the expediency of supplementing their two 25-ton hammers with a hydraulic forging-press, have built open-hearth furnaces, and in six months expect to be prepared to furnish rough-bored, rough-turned, and tempered material for guns of any required caliber.

Charles Cammell & Co. (Cyclops Steel and Iron Works) are making very large and important extensions to their enormous plant, and will at no distant day be prepared to supply, in addition to the products of their armor-making capacity, any amount of the heaviest steel parts and castings for guns and ships that the British Government will be likely to require.

John Brown and Company, limited (Atlas Works), are making similar development, and expect in a short time to have their 4,000-ton hydraulic press in operation.

COMPOUND ARMOR.

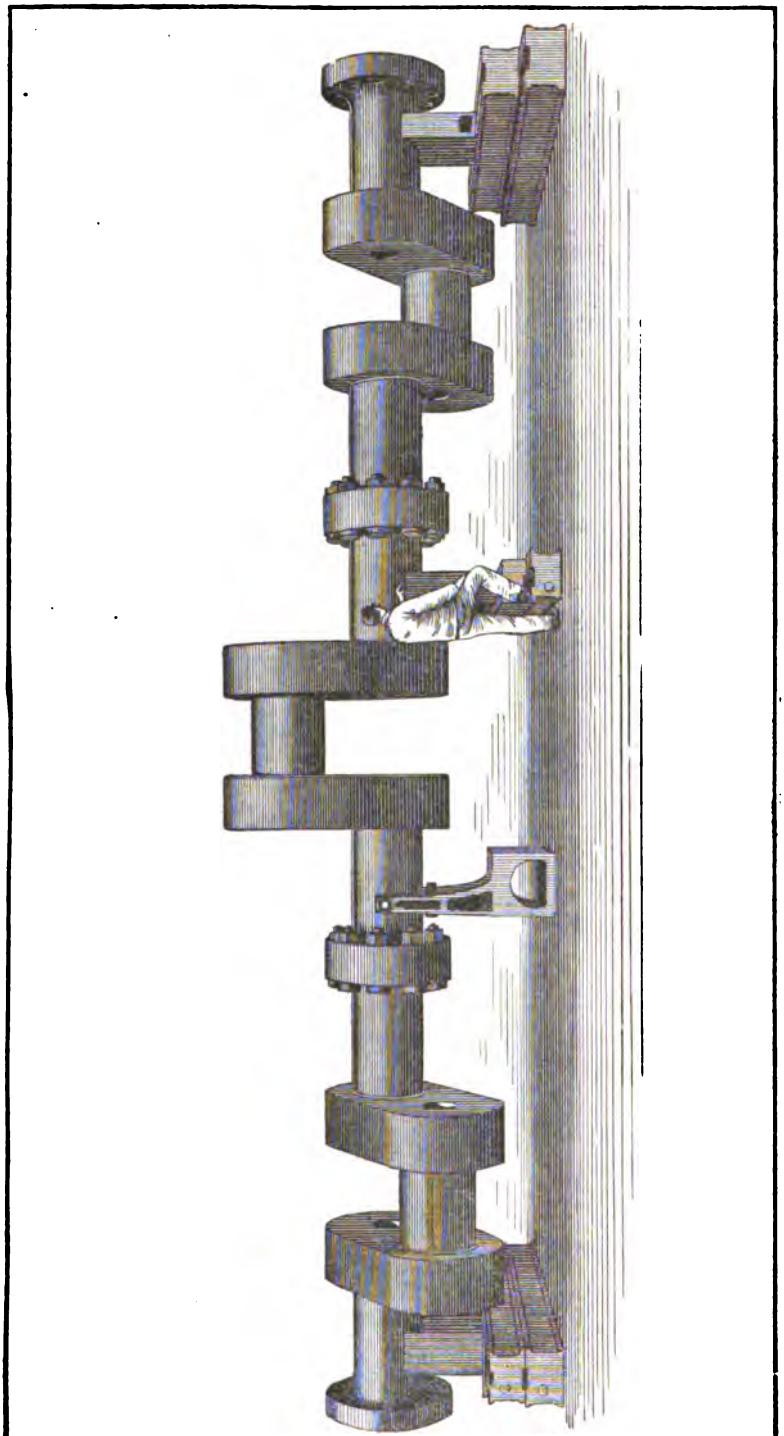
Regarding the efficiency of compound armor as manufactured on the Ellis and Wilson systems, Messrs. John Brown and Company state that "*they* are convinced that steel armor does not possess any advantage over the compound, as, although they could readily make both, they still adhere to the compound, and no other is used by the British Government." On the other hand, it must be remembered that in all the latest competitive armor-plate experiments the all-steel (Schneider) plate has been the victor.

The following description of the present method of manufacture was furnished the committee by John Brown and Company upon our request: "At the Atlas Works, Sheffield (John Brown and Company, limited), compound armor plates are made on the Ellis system, which is so designated from the name of Mr. J. D. Ellis, the chairman of the company, by whom the system was patented. Experiments have proved that the original idea of making compound plates with soft iron back and a hard steel face, and in about the proportions of two-thirds iron and one-third steel, remains the best. But a very marked improvement in the effective qualities of the plates has been attained by pressure previous to the final rolling. After the molten steel has been poured between the iron back plate and the worked steel front plate, and sufficient time has been allowed for the molten metal to solidify, each plate is placed in a press of 6,000 tons' capacity, and the thickness reduced by about three inches, the plates being made proportionately thicker in the first instance to admit this reduction."

WHITWORTH'S WORKS, MANCHESTER.

In Manchester, at the works of Sir Joseph Whitworth and Company, limited, the committee witnessed the working of what is no doubt the most efficient plant for the production of heavy gun material and shafting; and indorse the opinion already expressed by the Gun Foundry Board, that "as to the treatment of the metal after casting there can be no doubt of the superiority of the system adopted by Sir Joseph Whitworth over that of all other manufacturers in the world."

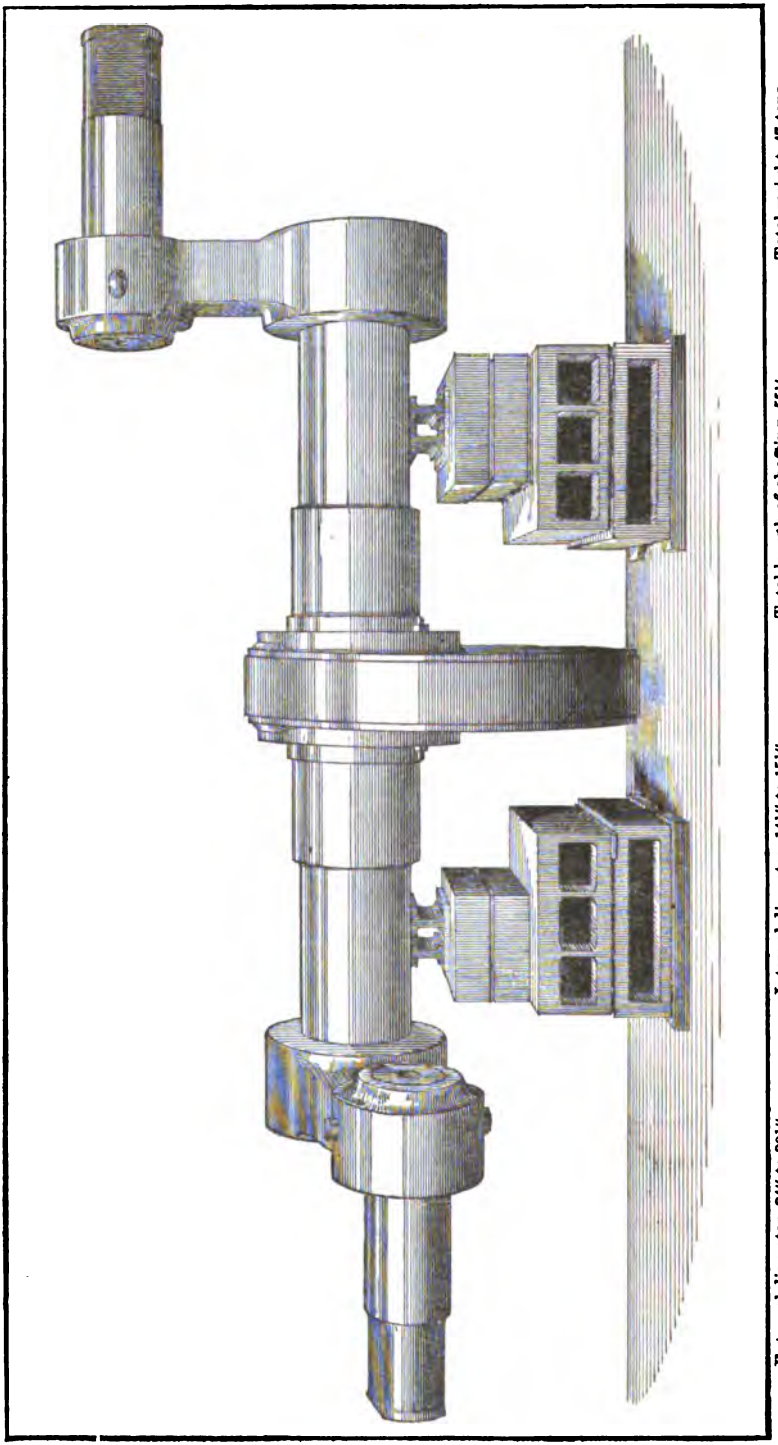
Plate 11.



Length over all, 39'.
Stroke, 6'.
Weight, 63 tons.
Crank-pins, dia. 26".
Diameter of shaft, 25".
Diameter of couplings, 45".

Shafting of the Atlantic Steamship "City of Rome." Made of fluid-pressed steel. Manufactured by Whitworth & Co.

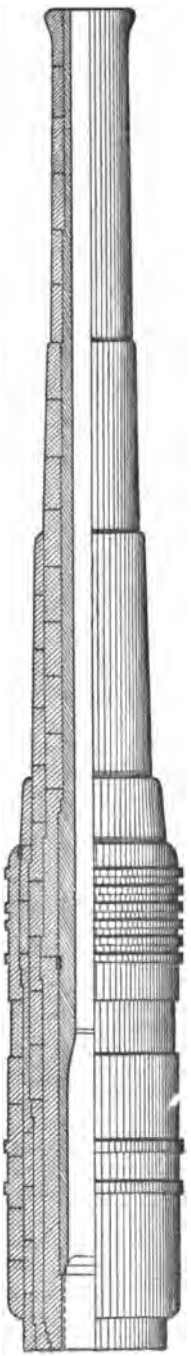
Plate 12.



External diameter, 24" to 30". Internal diameter, 14" to 15". Total length of shafting, 55'. Total weight, 47 tons.

Shafting for the Paddle steamer "Ireland". Manufactured by Whitworth & Co.

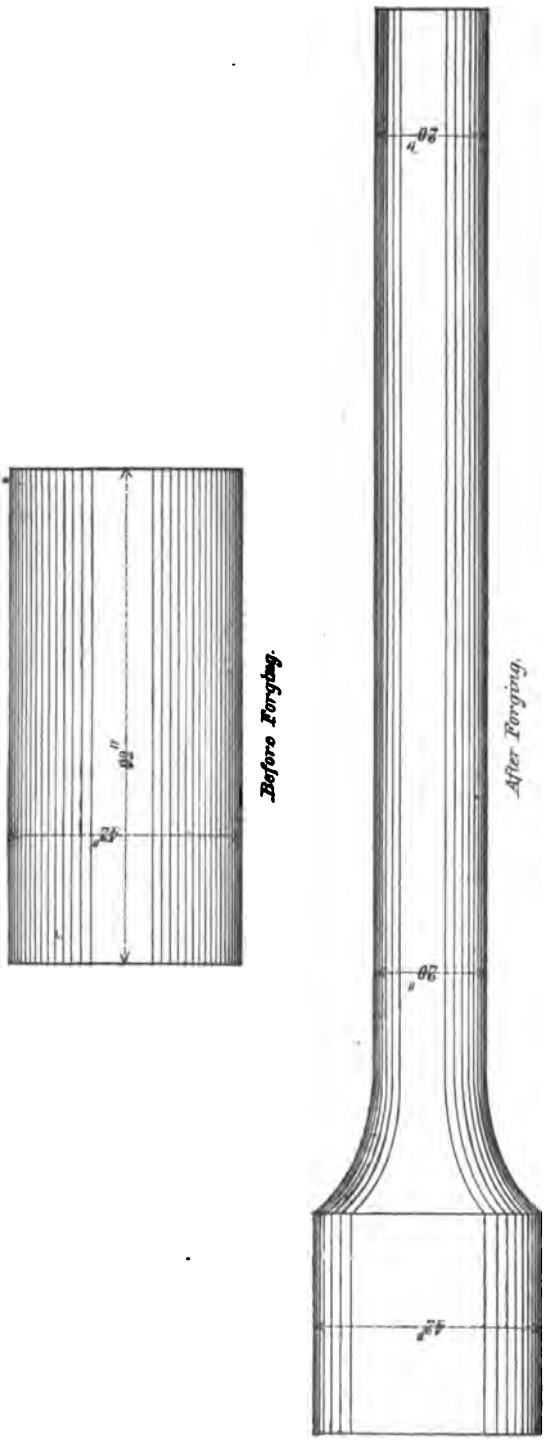
Plate 13.



Scale, ⅛

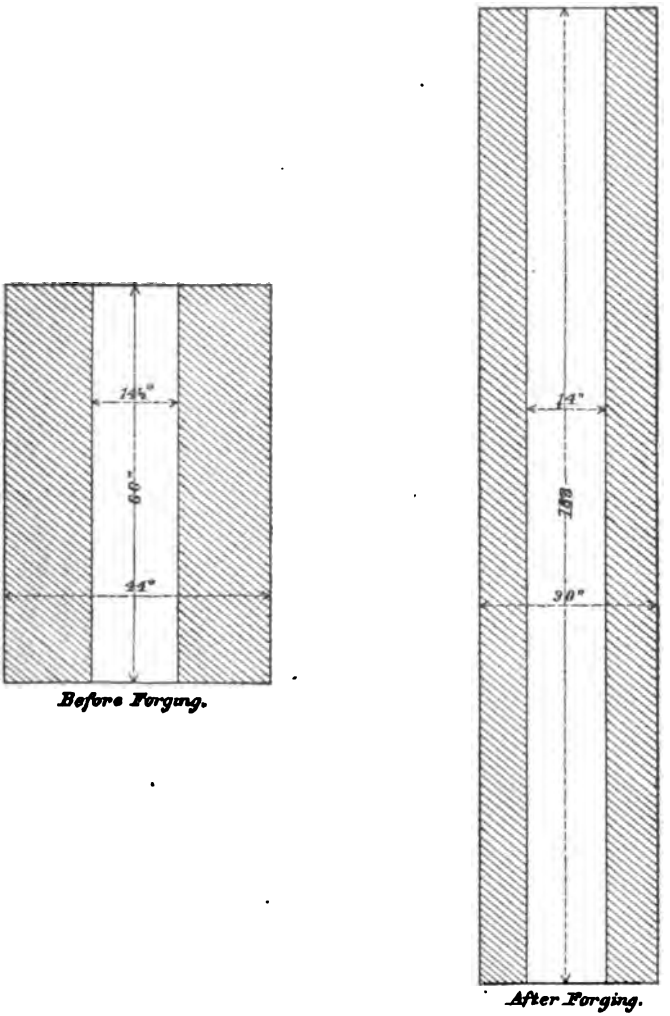
16.25-inch, 110-ton B. L. rifle. English.

Plate 14.



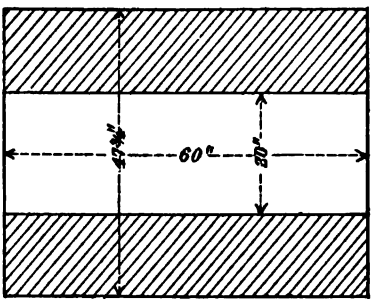
Drawing Ingot. Drawn down in one heat. Weight, 39,375 pounds. Whitworth Hydraulic Forging-press.

Plate 15.

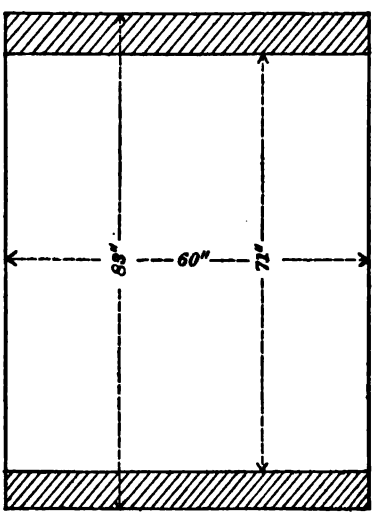


Drawing Hoop with Whitworth Hydraulic Forging-press. Drawn down in one heat
Weight, 28,250 pounds.

Plate 16.



Before Forging.



After Forging.
Weight of Hoop 224 cwt.
Enlarged in one heat.

Enlarging Hoop with Whitworth Hydraulic Forging-press.

The facility with which the operations were performed, the absence of noise, and the ease with which the enormous weights were handled—almost automatically—were particularly impressive. The forgings for the shafting of the Atlantic steamship City of Rome, Plate 11, the side-wheel steamer Ireland, Plate 12, and the tubes for the 110-ton steel guns, Plate 13, now in process of fabrication at Elswick, were manufactured here, and indicate the unequalled resources of this splendid establishment; further, the compressed air cylinders manufactured by Whitworth for the Whitehead torpedoes are considered superior to any others; and the British Admiralty require that "the propeller shafting and the working barrels of all the cylinders shall be made of Whitworth's fluid compressed steel," and that the crank shafts shall be made of the same or of Vicker's steel.

Plates 14, 15, and 16 show graphically the work performed by one of the Whitworth forging presses in the presence of the committee.

The following extract from the report of the Gun Foundry Board, pages 14–16, describes the processes:

In speaking of the Whitworth establishment at Manchester as unique, and of the process of manufacture at that place as a revelation, reference is specially made to the operation of *forging*. As to the assorting of ores and the treatment of metal in the furnaces, there is no intention to draw distinctions; but as to the treatment of the metal after casting, there can be no doubt of the superiority of the system adopted by Sir Joseph Whitworth over that of all other manufacturers in the world. The process here adopted has been kept singularly exempt from scrutiny. Even in the offices of the chiefs of artillery there can be found no information, within the knowledge of the board, which is at all satisfactory upon the subject. Whatever knowledge there is seems to come from hearsay—none from personal observation—and it is only from personal observation that the merits of the system can be fully appreciated.

The system consists in compressing the liquid metal in the mold immediately after casting, and in substituting a hydraulic press for the hammer in the subsequent forging of the metal.

The flask is made of steel, and is built up of sections united by broad flanges bolted together in such numbers as to accommodate the length of the ingot to be cast. All molds are cylindrical in form. The interior of the flask is lined with square rods of wrought-iron, longitudinally arranged, which form when in place a complete cylindrical interior surface. Where the square edges of these rods meet they are cut away both on the inside and on the outside, and at intervals of two inches small holes are drilled through between the rods, forming a channel-way from the interior to the exterior for the passage of gas and flame. The interior is then lined with molding composition. The flange at the bottom of the flask, as well as that at the top, is perforated with small holes, which act as a continuation to the perforations between the segments of the lining for the escape of gas.

The casting is made directly into the mold from the top. On the completion of the casting the mold is moved (by means of a railway at the bottom of the casting pit, which is a deep trench running parallel to the position of the furnaces) to a position under the movable head of the press, which is allowed to descend until the top is in contact with the metal in the mold, and in this position it is locked; a shower of metal is induced, which ceases almost as soon as commenced by the complete closing of the mold. The first impress felt by the metal is due to the weight of the head of the press alone. This pressure is gradually increased from below by hydraulic action, applied by four rams upon the table on which the flask rests, until the pressure exerted amounts to 6 tons per square inch. The interval from the commencement of the pressure until the maximum is reached varies with the size of the ingot, being for a 45-ton ingot as much as 35 minutes. During this time the flow of gas and flame from the apertures in the flanges of the flask, at top and at bottom, are continuous and violent, exhibiting the practical effect of the compression. This pressure is applied by the direct action of steam and pumping engines, and is indicated by a dial. At the end of this time the pump is taken off, and a uniform pressure of about 1,500 pounds per square inch is established by attaching an accumulator to the press, and allowed to remain until the metal is sufficiently cooled to insure no further contraction in the mold.

The contraction in length in the mold during the action of the pump, while the maximum pressure is being reached and sustained, amounts to one-eighth of the length of the ingot. After this effect has been produced, there is no further advantage derived from the pressure in the way of eliminating impurities, but the contrac-

tion, in cooling, still goes on, and the pressure by the accumulator is considered necessary, in order to follow up the metal as it contracts, for the purpose of preventing cracks being inaugurated at the end and on the exterior of the ingot by the adhesion of particles of the metal to the sides of the mold.

When cooled and reheated, the ingot is brought under the influence of the forging-press. This press is hydraulic, with a moving head, having the main hydraulic cylinder fixed in it, and it is provided with an arrangement of mechanism for raising and lowering the moving head of the press and for locking the same in any desired position. The press has four hollow pillars screwed part of their length, which are attached to the base of the press by nuts. On the top of the pillars is fixed a cast-iron head or table supporting two hydraulic lifting cylinders, the rams of which are fitted with cross-heads, carrying four suspension bars. These bars pass through the moving head, and are connected at the lower ends by cross-bars, which are fastened to the pressing ram. The moving head works between the base and the top or fixed head of the press, and is raised or lowered by the admission or exit of water from the under side of the rams of the lifting cylinders. The moving head can be firmly and rapidly locked at any height from the base which may suit the work to be operated upon. The moving head, as already mentioned, carries a forging or compressing cylinder, which forces a ram down upon the work. By attaching the compressing cylinder to and making it part of the moving head a short stroke can be employed when forging objects which may vary in size from a few inches to several feet in diameter.

This in general terms explains the working of the ram. The effect produced by it requires to be seen in order to be thoroughly appreciated, and is altogether different from that produced by the hammer. The heated ingot resists the blow of the hammer, but the insinuating, persevering effort of the press cannot be denied. The longer time (several seconds) during which the effort lasts is a great element in its successful effect. As pressure succeeds pressure the stability of the particles is thoroughly disturbed and a veritable flow of metal induced, which arranges itself in such shape as the pressure indicates; the particles are forced into closer contact, and the whole mass writhes under the constraint which it is impotent to resist.

The committee were impressed with the immensity of the plants required to turn out the supply demanded and the enormous capital exacted to efficiently conduct these works. In one establishment alone £2,000,000 have recently been invested to make such extensions as the direction deemed necessary.

SCHNEIDER'S WORKS, LE CREUSOT, FRANCE.

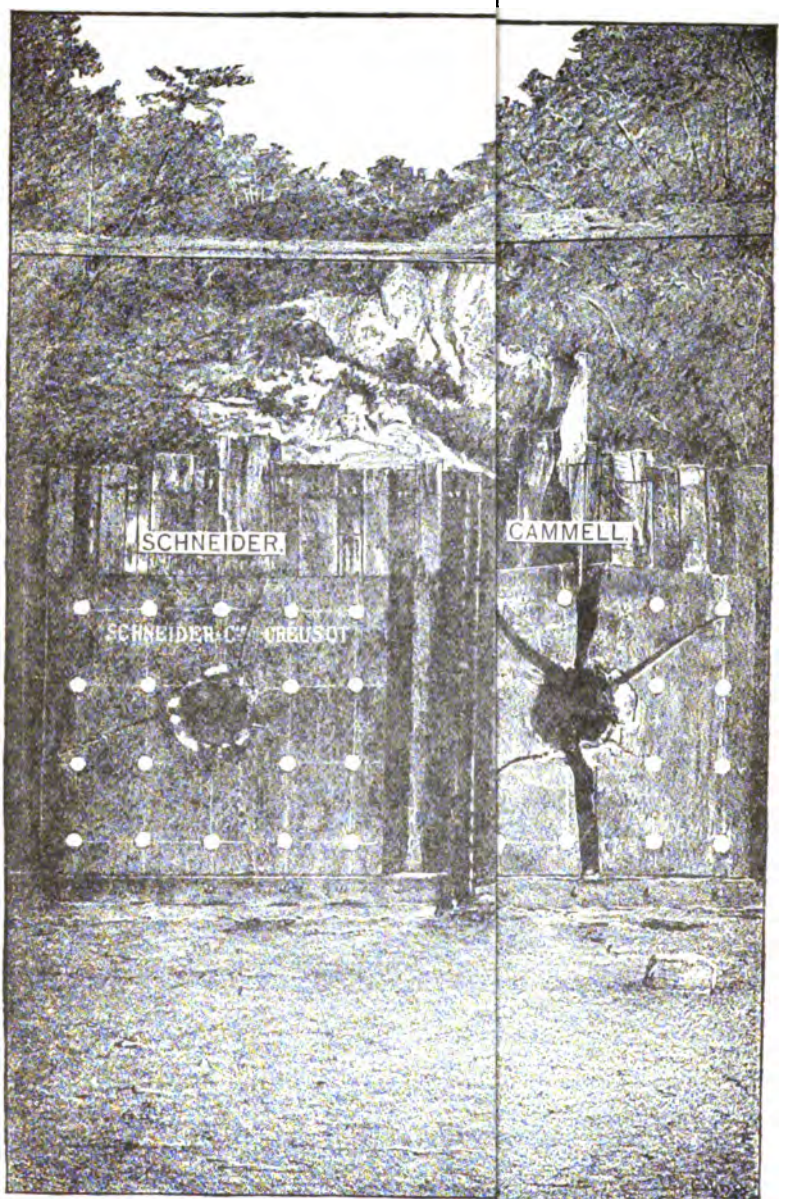
The committee regret that they were unable to accept the courteous and cordial invitation of Mr. Henry Schneider to visit the great works of Henry Schneider & Co., Le Creusot, France, to see the development that has taken place in an establishment that not only produces the best armor plates in the world and provides enormous quantities of ordnance material for guns of any required caliber, but also furnishes guns complete.

COMPETITIVE TRIALS OF ARMOR PLATES.

The following descriptions of the latest competitive trials of compound (wrought iron and steel) and steel armor plates show that steel has won as signal a victory over iron in armor plating as it has in gun material.

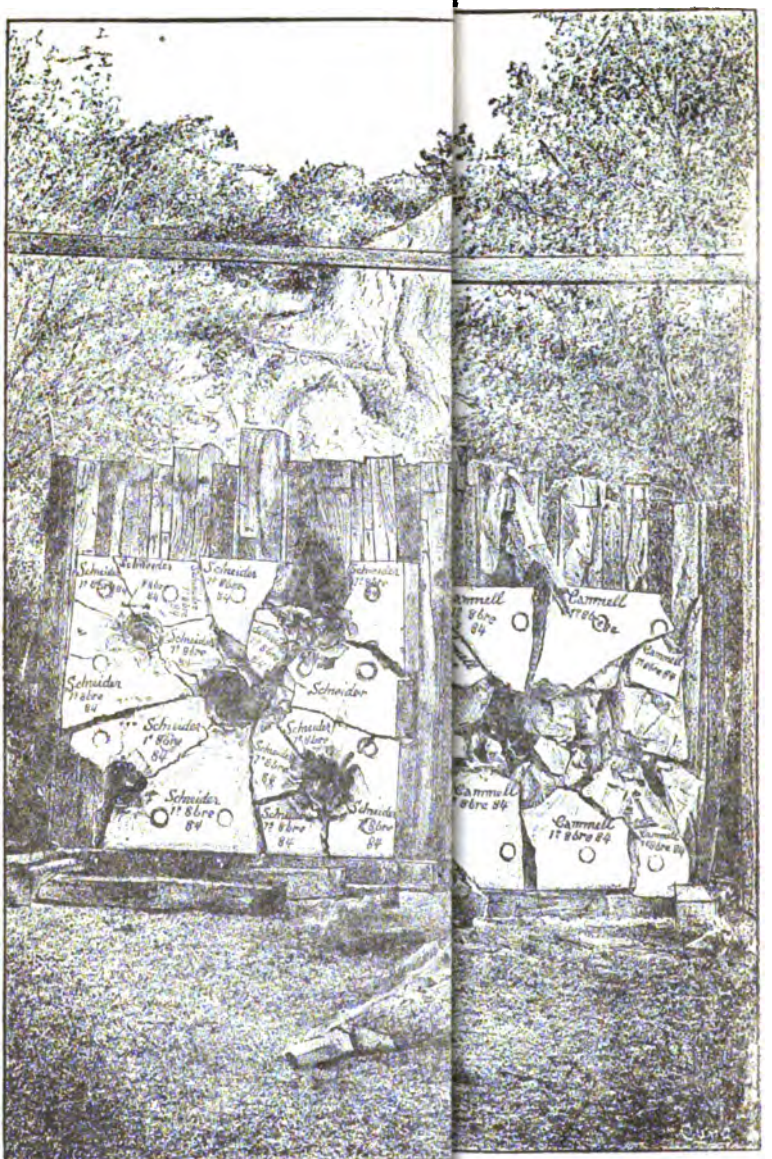
The latest public competitive trial was made by the Italian Government at Spezzia, in October and November, 1884. The object of the trial was to determine the relative endurance of the two kinds of plates when tested to destruction. The steel plate was supplied by Schneider, of Creusot, France, and the compound plates by Cammell & Brown, of Sheffield, England.

Each plate was 10 feet long by 8 feet 6 inches wide by 19 inches thick, weighed about 29 tons, and was secured by 18 Schneider bolts to a target equal in strength to the side of a ship, the targets being placed in front of a butt. The programme laid down by the Italian commis-



FRONT VIEW OF TUN.

Face p. 25

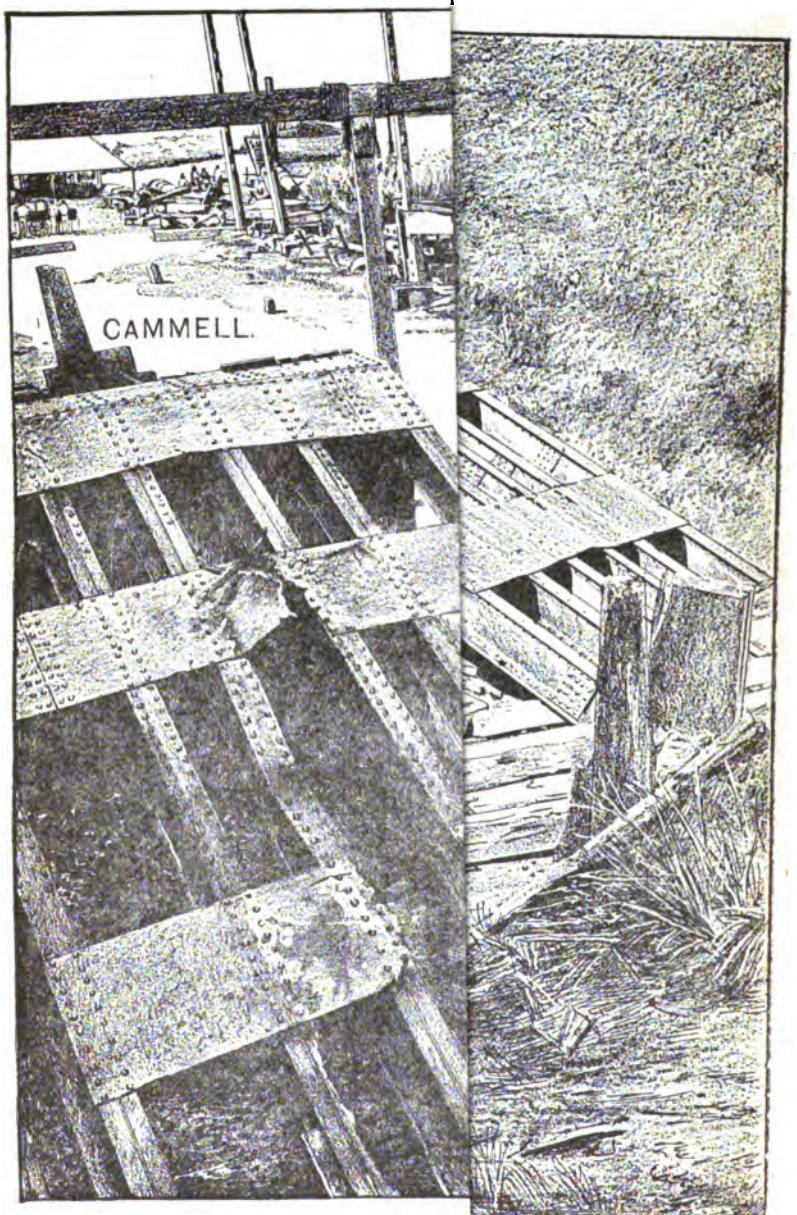


M. JOYCE, ENG., WASH., D. C.

FRONT V

Number of Shots Fired. { SCHNEI Total, 5 Shots. / BROWN " 3 " / CAMME " 3 "

Face p. 25



REAR VIEW OF GUN.

Face p. 25

sion was to fire, at 100 yards range, one shot weighing about 1,840 pounds from the 100-ton Armstrong gun at the center of each plate, and afterwards to fire four shots weighing about 850 pounds each from the 10-inch (about 30-ton) Armstrong gun at the four corners of the same plate.

The shot from the 100-ton gun was known to possess an energy sufficient to penetrate a wrought-iron plate 39 inches thick, and therefore would be able to penetrate all of the trial plates; the idea being to distress the plates as much as possible by the most powerful gun in existence, and then ascertain how much they would endure afterwards from the fire of a gun more nearly equal to them.

Plate 17 shows the effect of the fire of the 100-ton gun alone. The Schneider plate was penetrated as if by a punch; the hole was uniform in its diameter, and only 2 inches larger than the projectile, only three small radial cracks being visible. The Brown and Cammell plates were greatly damaged, the former having a portion of the steel face, nearly 5 feet in diameter, knocked off One radial crack in each plate was 10 inches wide, and the hole through the plate was 7 and 9 inches larger than the diameter of the projectile.

A very marked feature was the fact that the Schneider plate was so hot that it could not be touched within 2 feet of the hole for several hours, showing the vast amount of the energy of the projectile which it had absorbed. The heat of the Cammell and Brown plates was scarcely perceptible.

Plate 18 shows the face of the plates after the fire of the 10-inch gun. The Cammell and Brown plates only received two shots each from the smaller gun, and were then pronounced "hors de combat" by the commission. The Schneider plate, after receiving the four shots prescribed, was considered to be in condition to have received two more shots had it been considered necessary to continue the trials.

Plate 19 shows the rear of the targets after the firing was concluded. The framing of the targets was triangular in shape for greater strength. The names Cammell, Brown, and Schneider show where the armor plates are located. The projectiles were fired from the direction of the upper left-hand corner of the cut. It will be observed that the Schneider target is the only one having its frames and braces intact. The Schneider plate is the only one that would have kept the 10-inch projectiles out of a ship. The annexed tables give the details and effects of each shot as it was fired. As a result of this trial the Italian Government has adopted steel for all ships' armor, and has established a manufactory at Terni, near Rome, to manufacture it on the Schneider system.

The committee desire to express their appreciation of the attentions shown them by the officers of Her Majesty's service; of the courtesies of the Hon. Edward J. Phelps, United States minister to England; and to record their recognition of the valuable services rendered by Commander F. E. Chadwick, United States Navy, naval attaché, London, and Lieutenant Jaques, United States Navy, secretary to the committee, in assisting and expediting their investigations; also to call attention to the importance of having naval attachés in those countries where rapid developments in war material are taking place.

JOS. R. HAWLEY,
Chairman sub-Committee.

COMPARATIVE ARMOR-PLATE EXPERIMENTS, SPEZZIA, ITALY, OCTOBER, 1884. (See Plate 17.)

[Dimensions of plates: 10 by 8½ feet by 18.9 inches; weight of each plate, about 29 tons. Armstrong 17-inch 100-ton breech-loading rifle. Firing distance, 324 feet. Progressive Fossano powder of 2 to 3 grains per pound.]

Progressive number of shots, and dates of firing.	Kind of plate and name of maker.	Weight of powder charge.	Weight of projectile; Krupp hollow forged and tempered steel.	Velocity, feet per second.		Striking energy, foot tons.			Depth of penetration of projectile into plate.	Thickness of wrought-iron plate which would have been completely penetrated by an undeformed steel projectile, according to the Gâvre formula.	Remarks.
				Initial.	On striking.	Total.	Per inch of circumference of projectile.	Per square inch of section of projectile.			
1884.		*Pounds.*	*Pounds.*						*Inches.*	*Inches.*	
Oct. 1	Cammell, compound plate, wrought-iron back with steel face.	772, in four cartridges of 193 pounds each; ignition in rear.	Empty, 1799; filled, 1841.	1,883	1,870	45,856	853.96	201.23	Complete penetration.	38.7	The projectile completely penetrated the plate and the wood backing with great excess of power. The hole in the plate was 28 inches in diameter and the plate was broken into six large pieces by six radial cracks. One of these cracks was 10.4 inches wide. A number of fragments of the steel face strewed the ground in front of the target. The aperture in the face, representing the ship-plate (0.7 inch), was about 28 inches wide by 6 feet 7 inches high, and the hole made in the wood backing was partially filled with chips of wood and fragments of plate. The two neighboring braces were completely broken, the next two partially so; the horizontal stay was broken and thrown to the rear by the impact. Large fragments of the plate and projectile covered the ground between the plate and the butt, which was much shattered by the pieces that penetrated it. None of the bolts were driven to the rear, but the bent cupels and the rubber protruding from the joints indicated decided fatigue. The projectile was broken.

Oct.	1	Brown, compound plate, wrought-iron back with steel face.	773, in four cartridges of 198 pounds each; ignition in rear.	Empty, 1799; filled, 1841.	1,873	1,860	44,880	844.45	199.12	Complete penetration.	38.5	The projectile completely penetrated the plate and backing with great excess of power. The hole in the plate was about 26 inches in diameter, and the plate was broken into eight large pieces by eight radial cracks, one of them 10.2 inches wide. The steel face was detached all around the point of impact to a diameter of about 5 feet 3 inches, and a great many fragments covered the ground in front of the target. The aperture in the face, representing the ship-plate (0.7 inch), was about 23.6 inches wide by 5 feet 3 inches high, and the hole made in the wood was partially filled with chips of wood and fragments of the plate. The two neighboring braces were completely broken and the next two started. One of the edges was completely broken off and thrown violently against the butt. Large pieces of the plate and projectile were scattered about the ground between the plate and the butt, which was much shattered by the pieces that penetrated it. One bolt only, near the blow, was broken. The deforming of the washers and rubber of the other bolts showed great fatigue. The projectile was broken.
Oct.	1	Schneider, solid steel plate.	772, in four cartridges of 193 pounds each; ignition in rear.	Empty, 1799; filled, 1841.	1,873	1,860	44,880	844.45	199.12	Complete penetration.	38.5	The projectile completely penetrated the plate and backing, but with an excess of power sensibly less than that shown in the two preceding cases. The hole in the plate was clean and only 19.7 inches in diameter (very little larger than the diameter of the projectile). It was divided into three parts by three radial cracks, the largest of which was 1.6 inches. A capillary radial crack was also found on the left of the hole but not connected with it. No part of the face of the target was detached. The aperture in the face representing the ship-plate (0.7 inch) was about 26 inches wide by 4 feet 11 inches high, but the hole made in the wood was not filled with chips, proving that a less quantity of metal was carried away from the plate and thrown to the rear. For the same reason less *débris* was found in the rear than with the other targets, and the edges of the center suffered less. Only one of the neighboring braces was completely broken. A meniscus-shaped piece, detached from the back of the plate by the projectile, fell at the foot of the target. Fragments of the projectile were found at the foot of the butt, into which the ogival point had scarcely penetrated. All of the bolts had held perfectly and showed no signs of fatigue, although their size was less than those used in the English plates. The projectile was broken.

COMPARATIVE ARMOR-PLATE EXPERIMENTS, SPEZZIA, ITALY, OCTOBER AND NOVEMBER, 1884. (SEE PLATE 18)—Continued.

[Dimensions, of plates, 10 feet by 8 feet 6 inches by 18.9 inches; weight of each plate, about 29 tons. Armstrong 10-inch breech-loading rifle, English prismatic cocoa powder; firing distance, 240 feet.]

Progressive number of shots, and dates of firing.	Kind of plate and name of maker.	Weight of powder charge.	Weight of projectile; Krupp hollow, forged and tempered steel.	Velocity, feet per second.		Striking energy, foot tons.			Depth of penetration of projectile into plate.	Thickness of wrought-iron plate which would have been completely penetrated by an undeformed steel projectile, according to the Gâvre formula.	Remarks.
				Initial.	On striking.	Total.	Per inch of circumference of projectile.	Per square inch of section of projectile.			
1884.		*Pounds.*	*Pounds.*						*Inches.*	*Inches.*	
											Conditions of trial.—After having received a shot from the 100-ton gun, as described in the preceding table, each plate was to be in condition to receive four shots from the 10-inch Armstrong; the four blows to be given in the four angles of each plate at a distance of not less than 2½ calibers from either edge.
Oct. 21	Brown, compound.	270	Empty, 454; filled, 470.	2,172	2,158	15,425	494.28	198.27	12.6	26.3	One-third of the plate was thrown to the ground, uncovering the backing. Four bolts were broken and thrown to the rear. The backing was seriously injured, and the projectile was broken.
Nov. 4	Brown, compound.	270	Empty, 454; filled, 470.	2,182	2,168	15,580	498.2	200.67	14.0	26.5	Three-quarters of the backing was uncovered, five bolts broken and thrown to rear. The backing was badly damaged, and the projectile was broken. The plate was considered to be unable to endure any more shots.
Nov. 5	Schneider, steel.	270	Empty, 454; filled, 470.	2,183	2,168	15,580	498.2	200.67	9.1	26.5	Four radial cracks from 0.2 to 0.8 of an inch wide. All the pieces of the plate remained in place. The rear of the target was entirely intact. The bolts were uninjured and showed no sign of fatigue. The projectile was badly broken, the ogive remaining in the imprint.

Nov. 5	Schneider, steel.	270	Empty, 454; filled, 470.	2,135	2,170	15,602	499.02	200.67	11.4	26.5	One radial crack; 3 square feet of the backing was uncovered. The rear of the target was intact. A bolt of one of the pieces dislodged remained in place. The projectile was badly broken, the ogive remaining in the imprint.
Nov. 5	Schneider, steel.	270	Empty, 454; filled, 470.	2,172	2,157	15,406	493.19	196.44	10.8	26.3	Four radial cracks; limited to the broken fragment. All the pieces remained in place. The rear of the target was uninjured. The bolts were also well in place with no sign of fatigue. The projectile was broken, the ogive remaining in the imprint.
Nov. 6	Schneider, steel.	270	Empty, 454; filled, 470.	2,165	2,151	15,320	490.69	196.44	10.6	26.1	Three radial cracks; 3 square feet of backing exposed at the lower left-hand corner. The lower left-hand bolt fell intact behind the target. All the other pieces of the plate remained in place. The projectile was much broken, the ogive remaining in the imprint. The plate and backing would admit of two more shots being fired.
Nov. 7	Cammell, compound.	270	Empty, 454; filled, 470.	2,164	2,149	15,298	489.86	196.44	Not measurable, because the fragments were totally destroyed.	26.1	The piece struck was thrown from the target, exposing about 14 square feet of the backing. Many pieces of the plate, weighing altogether about 5 tons, were scattered in front of the target. Two edges were broken and the projectile was broken, but much less than in the case of the Schneider plate. The bordé was driven back a little.
Nov. 7	Cammell, compound.	270	Empty, 454; filled, 470.	2,149	2,135	15,094	483.19	194.12		25.9	The piece struck was broken into seven fragments, several of which were buried 6.7 inches into the backing. The steel face was torn off from nearly 22 square feet of the plate and two of the edges were broken. The plates representing the ship plate were driven back and split; the lower part would have caused a leak. Two pieces of the plate weighing 661 pounds fell behind the target, passing through the hole made by the central shot. The projectile was broken as in the preceding shot. As in the case of the Brown plate, the Cammell plate was also judged to be unfit for further trial after this second shot.

REPORT OF SUBCOMMITTEE ON A VISIT TO THE NAVAL ORDNANCE PROVING GROUND.

ANNAPOLIS, MD., *July*, 1885.

Accompanied by Senator J. N. Dolph, of Oregon, and Lieutenant Jaques, U. S. Navy, the committee paid a visit of inspection to the Naval Ordnance Proving Ground, where they witnessed a large number of interesting experiments, under the direction of Commander William M. Folger, U. S. Navy, and his assistants. The committee were impressed with the earnestness and intelligence with which the experimental work has been conducted, particularly under the unfavorable conditions of location and the very small amounts available for such work. Frequently the committee were forced to wait until the schooners and small craft passed out of range before some of the experiments could be made. After inspecting the offices, instruments, small machine- and tempering shops, the 6-inch steel-hooped, breech-loading rifle, fabricated at the Washington navy-yard, for the dispatch-boat Dolphin, was fired with a scaling charge of 15 pounds of hexagonal powder, and afterwards with service charges of 50 pounds of American brown (cocoa) powder and 100-pound steel projectiles. The action of the gravity return-carriage (also manufactured at the Washington navy-yard) upon which it was mounted, and of the breech mechanism, was in every way satisfactory. The pressure-gauges showed a pressure of a little over 14 tons to the square inch.

All except one of the shots were fired into butts, in order to recover the projectiles for further experimental use.

For practice with the Hotchkiss rapid-firing guns, Commander Folger tempered an American-made, 47-millimeter (1.85-inch) projectile in the presence of the committee, and fired it, under similar conditions with a foreign armor-piercing projectile of the same caliber, against $3\frac{1}{2}$ inches of steel (in plates) and 3 inches of oak backing. The annexed cut represents the appearance of the two projectiles after fire.

Fig. 2, the foreign projectile, penetrated the plates and backing, but was "set up" as shown. Fig. 1, an American-made, chrome steel, Folger-tempered projectile, penetrated the $3\frac{1}{2}$ inches of steel, 3 inches of oak, and 4 feet of sand, and with the exception of a few scratches, represented in the cut, produced by the rifled motion in the sand, the projectile was in as perfect condition as before the firing; in fact so perfect that it was afterward inserted and pushed through the bore without its rotating ring. I have preserved this projectile * for the purpose of exhibiting its remarkable character.

Another very interesting experiment was made to show the effect of a 47-millimeter projectile fired against a 1-inch *cast* steel plate of excellent quality. The plate was easily broken into numerous fragments, which flew about the grounds in all directions, showing the unfitness of *cast* steel, of even this excellent quality, to meet the demands of strength and tenacity for armor, gun, and other ordnance material; and, although

*I have been informed that Commander Folger has succeeded in getting a 47-millimeter projectile of chrome steel superior to this; it was manufactured by the Simond's round forging-machine. (Senator Morgan.)

the steel in question had been guaranteed to be free from blow-holes (gas-holes) the first fragment examined contained a hole as large as a moderate-sized pea.

Experiments were also made with the Folger high-power musket (Remington rifle, caliber .50, with chamber lengthened to contain a

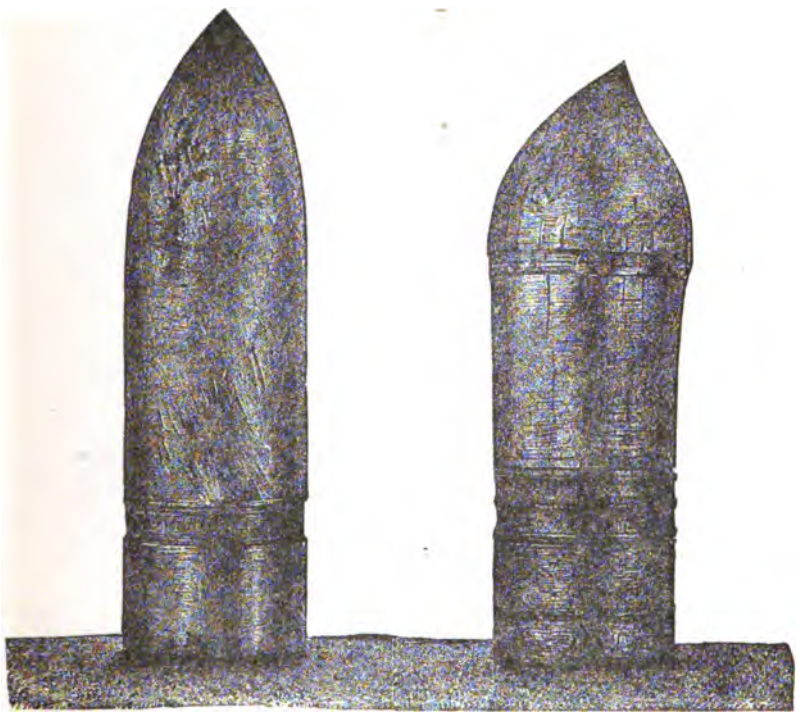


FIG. 1. FIG. 2.

charge of 202 grains). Steel projectiles of 430 grains easily pierced 1-inch wrought-iron plates. The slight recoil was noticeable. Commander Folger has reported to the Naval Ordnance Bureau that "it seems probable that with the high-power musket recently submitted to the Bureau, a muzzle velocity of 2,200 feet per second can be obtained with a solid steel projectile 3.5 to 4 calibers in length, which should give a penetration in wrought-iron of 1.5 inches.

JOHN T. MORGAN,
United States Senate, Chairman Subcommittee.

STATEMENT

OF THE

SECRETARY OF THE NAVY

IN REPLY TO

THE RESOLUTIONS OF BOTH HOUSES OF CONGRESS FOR THE APPOINTMENT OF COMMITTEES ON ORDNANCE AND NAVAL CONSTRUCTION.

JULY 12, 1884.

NAVY DEPARTMENT,
Washington, D. C., July 12, 1884.

GENTLEMEN: Referring to the resolutions of both houses of Congress for the appointment of Committees on Ordnance and Naval Construction, I have to submit, in response to requests, the following statement.

The subjects covered by the resolutions may be classified as follows:

I. The capacity of steel-works to make steel for guns and armor.

II. The character and sufficiency of machinery in navy-yards and in private works for the construction of guns, engines, and ships.

III. The best method, whether by Government or by contract, and the best location, for the manufacture and construction of guns, engines, and ships.

I.—THE CAPACITY OF STEEL WORKS TO MAKE STEEL FOR GUNS AND ARMOR.

STEEL AND GUNS.

The accompanying copies of the "Gun Foundry Board Report" (Inclosure A), and of a work entitled "The Establishment of Steel Gun Factories in the United States" (Inclosure B), contain complete information as to the means adopted by European Governments for providing modern steel guns, a comprehensive statement as to the manufacture of armor for vessels, and the recommendations of the Board above named which was appointed by the President in an order of April 2, 1883:

> For the purpose of examining and reporting to Congress which of the navy-yards or arsenals owned by the Government has the best location and is best adapted for the establishment of a Government foundry, or what other method, if any, should be adopted for the manufacture of heavy ordnance adapted to modern warfare, for the use of the Army and Navy of the United States, the cost of all buildings, tools, and implements necessary to be used in the manufacture thereof, including the cost of a steam hammer or apparatus of sufficient size for the manufacture of the heaviest guns.

The report was presented to the President February 16, 1884, and was favorably received by Congress. The Board recommended that the gun material should be purchased from our own steel manufacturers, and that two gun factories should be established under the control of the Government—one for the Army at the Watervliet Arsenal, West Troy, N. Y., and one for the Navy at the Washington navy-yard, District of Columbia, for the assembling of the parts and final fabrication of the guns.

The Board considers that every inducement should be offered to attract the private industries of the country to the aid of the Government in providing ordnance for the Army and Navy, and recommends that a sum of money should be fixed as a permanent yearly appropriation to be expended for this purpose, being satisfied that, with such a guarantee

against loss, the required material will be produced by our own private steel works.

The treatise on "The Establishment of Steel Gun Factories in the United States," published by the United States Naval Institute, is an amplification of the report of the Gun Foundry Board, by Lieut. W. H. Jaques, United States Navy, member and secretary of the Board.

The Gun Foundry Board has been reconvened by departmental order, and directed to report in what annual installments appropriations can most economically be made for the provision of modern ordnance, and to prepare plans and estimates for the preparation and purchase of plant for gun factories to complete guns, for the Army and Navy, from 6 inch caliber to 16-inch caliber, including buildings and shrinking-pit.

The Board addressed a circular letter May 15, 1884 (Inclosure C), to the leading steel manufacturers of the United States calling their attention to the following paragraph contained in the instructions to the Board:

In case the Board shall be of opinion that the manufacture of the necessary gun material should be developed in this country by contracts with American manufacturers, the Board may communicate with and receive proposals from such manufacturers; and will cause to be prepared and submitted suitable contracts in detail, ready for execution, in case they shall be approved by Congress, and will make specific recommendations concerning the same.

The circular proceeded to say:

You will see from the report that the Board is very decidedly of opinion that the gun material should be developed in this country, and the object of now addressing you is to request from you such proposals as may guide the Board in its recommendations as to the annual appropriations to be made.

In whatever particular your works may be deficient in the appliances required, you are requested to consider the outlay necessary to efficiently equip your establishment, and to determine the size of contract for annual supply of gun material for a term of years, that will justify you in incurring this expense for plant, your remuneration to be derived solely from the price paid by the Government for the material after passing the tests required.

As this subject is now before Congress, you are requested to provide the information asked for at your earliest convenience. In considering the matter of a plant for the manufacture of gun material, the Board suggests that you do not lose sight of its availability for the manufacture of armor, for which a call may be made by the Government.

Replies to the above circular have been received from the Cambria Iron Company, of Johnstown, Pa., and the Midvale Steel Company, of Nicetown, Pa., stating that they are carefully considering the subject; and the Tredegar Iron Works, of Richmond, Va., have proposed to erect a plant, if the Government will advance the moneys.

GUNS FOR THE NEW CRUISERS.

To provide for the armament of the new steel cruisers, orders and contracts have been made as follows: With the Midvale Steel Company, of Nicetown, Pa., for steel for twenty-one 6-inch and two 5-inch breech-loading rifles; with Charles Cammell & Co., Sheffield, England, for steel for three 8-inch breech-loading rifles; and with Sir Joseph Whitworth & Co., Manchester, England, for steel for five 8-inch breech-loading rifles.

Part of the steel for the great guns has been received, both from Philadelphia and England, but the remainder cannot be expected before winter, as the manufacturers have fallen behind their expectations in regard to time of delivery.

Some of the guns are now being fabricated at the Washington navy-yard. Contracts are pending with the South Boston Iron Works and

the West Point Foundry Association for the fabrication of eleven of the 6-inch and four of the 8-inch guns.

It is also intended to build some of the guns in the navy-yard, Boston. The carriages are all to be built at the navy-yard, Washington.

ARMOR.

No proposals were received from this country in answer to the advertisement of August 20, 1883, for compound armor-plates for the turrets and pilot-house of the double-turreted monitor Miantonomoh, and the contract was awarded to the only bidders, Messrs. John Brown & Co. and Charles Cammell & Co., of Sheffield, England, through their agents, Messrs. William H. Wallace & Co., of New York. (Inclosure D.)

A circular letter was sent, June 20, 1884, by the Navy Department to the leading steel manufacturers of this country requesting them to inform the Department whether they would be prepared to manufacture armor for the monitors now in course of construction, informing them that bids would be admitted for either all steel or compound armor, and asking for the earliest notice of the probability of receiving bids from American manufacturers.

The replies indicated the absence in this country of a suitable plant for the production of the required armor. Inquiries were, however, received from the Midvale Steel Company and Pittsburgh Steel Works, as to the kind of armor the Government would desire, and the time of delivery of the plates. The Cambria Iron Company made no written reply to the Department's circular letter, but sent their chief engineer, Mr. Joseph Morgan, jr., who has been furnished with all information in regard to the supply of armor for the monitors, and in reference to the tests as far as decided upon; and he has inspected the drawings in the Bureau of Construction and Repair.

The Department, in its replies of July 1 and 8 to the above inquiries, stated that "it does not at this time express any preference for all steel or for compound armor," and it has prepared memoranda relating to the character of armor, mode of manufacture, and comparative tests. Of all the steel manufacturers addressed, included in a list which is appended, but three have shown any ability or disposition to undertake the manufacture. (Inclosures E and F.)

The Department will be glad to place at the convenience of the committees any of the material now in the possession of the boards appointed to investigate the subjects of the resolution, and it is important, in view of the information recently acquired by the Gun Foundry Board, that its members should appear before the committees.

II.—THE CHARACTER AND SUFFICIENCY OF MACHINERY IN NAVY-YARDS AND IN PRIVATE WORKS FOR THE CONSTRUCTION OF GUNS, ENGINES, AND SHIPS.

The question as to the condition of the plant in the navy-yards and the uses to which the several yards should be put is fully treated in the report of the Commission on Navy-Yards, dated December 1, 1883, and contained in Senate Ex. Doc. No. 55, Forty-eighth Congress, first session. (Inclosure G.). A summary of the conclusions of the Board is to be found in the annual report of the Secretary of the Navy of December 1, 1883, pages 15 and 16. (Inclosure H.) It appears that the Commission advised a reorganization and concentration of the mechanical departments of those yards which might be kept open for the construction or

repair of vessels, so that there should be but one shop in each for the performance of any one class of work, and that each of the several articles that form part of the outfit of a ship should be made in one yard only. The Commission also recommended that certain yards be closed, and others kept in use as general working yards, or only for special branches of manufacture. The recommendations upon which the members of the Commission were agreed have in general been carried out.

In this connection the Department would call attention to the following statement in the annual report for 1883:

Much difficulty has been experienced in effecting navy-yard reforms, owing to the opposition of persons interested in the existing system, not only to closing the repair shops in yards to be hereafter kept only as naval stations and arsenals, but also to concentration and economy at yards which are to be kept open for work. The assistance and specific directions of Congress should therefore be sought and effectively accorded. The arguments and facts which show that reforms should be instituted are overwhelming. The change of naval construction from wooden to steel ships would of itself involve a revolution in methods of work. With but little more than thirty vessels in commission, only five or six have required repairs at any one time, and by distributing these among as many navy-yards, the cumbrous organization and heavy expenditures at each yard have been hung upon and charged to the one ship then in hand with the results which published records have shown.

This subject will be again referred to later in this communication.

III.—THE BEST METHOD, WHETHER BY GOVERNMENT OR BY CONTRACT, AND THE BEST LOCATION FOR THE MANUFACTURE AND CONSTRUCTION OF GUNS, ENGINES, AND SHIPS.

GUNS.

The question as to the manufacture of guns is fully treated in the "general summary of conclusions" in the report of the Gun Foundry Board, pages 46 to 51, as follows:

GENERAL SUMMARY.

The foregoing presents the chief points of information that have been gained by the investigations of the Board.

As examples of a practical partnership between a Government and a private company in working towards a national object, the experiences in England and in Russia are very instructive and warn against the adoption of such a system. In England, the Government, in addition to paying, during several years, very high prices for articles delivered, was forced to pay £65,000 to close an agreement; while the company, besides the profits on manufacture, came into possession of a complete working plant at a mere nominal valuation.

In Russia, the Government finds itself involved with a stock company, paying excessive prices for what it receives, and discovers no way of relief except by buying up shares and operating the establishment as a Government foundry.

As an example of depending almost entirely on private works, Germany is a perfect instance. The works of Mr. Krupp are practically the sole source of supply of the German artillery. In such a case the Government must be the slave of the corporation, and subject to its whims, caprices, and conveniences. It needs no argument to show the dependent condition of the Government under such a rule; it might prove a source of the greatest embarrassment. The Board is well informed that some ten or eleven years ago the artillery officers were very restive under this load, and were making strenuous efforts to be relieved from it, but without success. It is hardly to be supposed that time has quieted the feeling of dissatisfaction.

As an example of depending alone on Government works, France was a perfect instance before the Franco-German war. During the period referred to the Government foundries were the sole source of supply of the armament of the country; the officers charged with the work formed a close corporation; their action was never exposed to the public; their ideas were never subjected to criticism; the ingenuity and inventive talent of the country were ignored and resisted, and no precaution was thought necessary to provide a supply in case of need of rearmament. The result is well known; a great crisis came; the Government works were inadequate to meet

the additional demands made upon them, and the patriotic efforts of private establishments were inadequate to produce all the material that was needed. How entirely France has now altered her system is shown in a previous part of this report; her present practice is theoretically perfect, and it has proved to be practically efficient. Her Government establishments are still retained, but as gun *factories* simply, in which the parts are machined and assembled, but for *foundry* work she depends upon the private industries of the country, and many of these works have found it to their profit to establish gun factories which supplement the Government factories to a great extent.

The conclusions of the Board on this subject accord with the plain teachings of these historical instances. It accepts the system now pursued in France as the proper standard for imitation, and recommends that in inaugurating the manufacture of war material in our own country a conformity as close as circumstances will admit to the plans which have proved so successful in France should be observed.

Having reached this conclusion, the Board is now prepared to dispose of the propositions into which, as stated on the seventh page of this report, the second interrogatory in the act of Congress was divided. The first proposition was thus presented, viz:

"That the Government should supplement the plants of some of the steel workers of the country with such additional tools and implements as would enable them to turn out finished steel cannon."

The adoption of this proposition would involve the Government in the embarrassments which now exist in Russia, and which we have seen were so costly to the English Government in its partnership with the Elswick Ordnance Company.

The Board does not approve of such joint action.

The second proposition was thus presented, viz:

"That the Government should give contracts of sufficient magnitude to enable the steel workers of the country to supply the finished guns without its direct aid."

This proposition, if adopted without any qualification, would make the Government dependent entirely upon the private industries of the country, which might combine to the detriment of the public service. The Government would have no guard against extortion and would be powerless against a combination. An actual instance of such a combination is cited in a previous portion of this report as having taken place in France, but the independent position of the Government made the effort futile.

The Board does not approve of this proposition taken by itself.

The third proposition was thus presented, viz:

"That the Government should establish on its own territory a plant for the fabrication of cannon, and should contract with private parties to such amounts as would enable them to supply from the private industries of the country the forged and tempered material."

This proposition is approved by the Board and is regarded as the foundation upon which our system of manufacture should be built up. If this be done, and the Government made secure by the possession of works of its own, there is every reason to adopt in addition the idea embodied in the second proposition in order to *supplement* the Government establishments.

A state, with any pretensions to military power, should provide itself with factory facilities on a sufficient scale to perform the work of establishing standards, making experimental guns and fabricating cannon on a moderate scale; but it is not considered judicious to concentrate in the Government establishments all the work of fabrication or to include within their operations the preparation of such material as can be provided by the private industries of the country. In the case under consideration the purchase of the steel required for cannon will stimulate our own manufacturers and interest them in the operations of the Government.

The Board is thus led to the conclusion that it is not advisable to embark in the establishment of a gun *foundry*, properly so called, but that it is more judicious to establish gun *factories*, and to purchase the material from our manufacturers.

At present the steel manufacturers of our country are not prepared to produce the material required for the larger calibers, and the important question arises, what means shall be adopted to induce them to study the subject and embark in the manufacture on a large scale? They cannot be expected to do this at a sacrifice of their own interests. This object can only be achieved by holding out a fair prospect of ultimate remuneration for the expenditures necessary to undertake the work, and this can only be done by the action of Congress.

If, then, Congress shall conclude to arm the country it will be necessary that a sum of money shall be fixed as a permanent yearly appropriation to be expended for this purpose, the amount to be assigned proportionally between the War and Navy Departments. With such a guarantee against loss the Board is satisfied that the required material for cannon will be forthcoming from our own steel works.

It would not be necessary for the Government to be associated with a large num-

ber of firms for the supply of its material, for it is probable that the private establishments that would take up the subject would only be those with large available funds which they would be willing to put into a special plant, and for remuneration on which they would be willing to wait a reasonable time. The permanent appropriation would give them surety of ultimate profit, the only condition being success in providing the material that would be indicated in their contracts. From personal intercourse with some of the leading manufacturers the Board is led to believe that the plan will have the effect of guiding the private industries of the country to the aid of the Government in developing this work of national importance.

It may be added that although the manufacture of armor plates for ships and fortifications was not referred to this Board for investigation, the erection of plant for providing modern cannon would go far towards reducing the outlay requisite to enable our great steel manufacturers to meet another pressing want of the Government.

The chief expense to be considered by private parties is that of the *forge*, but by the substitution of the hydraulic press for the hammer economy will be consulted and better results obtained. The Board is unanimous in approving the use of the press for all forging purposes, and recommends it to all who may embark in the manufacture of gun metal for the Government.

In conclusion the Board submits its replies to the three interrogatories contained in the act of Congress:

(1.) "Which of the navy-yards or arsenals owned by the Government has the best location, and is best adapted for the establishment of a Government foundry?"

The Board does not recommend the establishment of a Government foundry, properly so called, which shall provide for the manufacture of steel and the fabrication of cannon. It considers that every inducement should be offered to attract the private industries of the country to the aid of the Government in providing ordnance for the Army and Navy, and that the steel manufacturers should be called upon to provide the material.

The Board recommends the establishment of two gun factories under the control of the Government and selects the—

Watervliet Arsenal, West Troy, N. Y., as the site for the Army, and the

Washington navy-yard, District of Columbia, as the site for the Navy.

The Board is unanimous in recommending that the Army and the Navy should be provided with separate establishments. This has always been the custom in France, producing good results, the reverse has been the practice in England, producing bad results. Dissatisfaction from this cause has existed for many years in the English Navy, and the Admiralty has recently brought about a revolution in the system, so far as the supply of gun-carriages is concerned, by obtaining from Parliament a separate and distinct appropriation with which it is providing the English Navy with the Vavasseur gun-carriage in opposition to the will of Woolwich.

In the administration of the War and Navy Departments of the United States, each service has charge and direction of its own distinct system of artillery, hence if but one gun factory be provided, its control must be placed in the hands of a mixed commission. This must lead to conflict of authority and to embarrassments of all kinds, in which the heads of Departments must necessarily become involved. A close scrutiny of the practical difficulties that would arise in conducting the affairs of a gun factory in such mixed interests develops obstacles that would be insuperable even with the most harmonious intent.

In the selection of the sites mentioned, it is not intended to convey the idea that they are regarded as in every way adapted for the purpose, but, as the scope for choice is limited, they are considered the most advantageous. The Board does not recommend the purchase of new sites, as this would open so wide a field for selection as to embarrass the question by arousing local interests throughout the country.

(2.) "What other method if any (apart from the establishment of a Government foundry), should be adopted for the manufacture of heavy ordnance adapted to modern warfare, for the use of the Army and Navy of the United States?"

With Government gun *factories* established for both the Army and the Navy, there will be still needed the hearty co-operation of the private industries of the country. This cannot be aroused unless there is held out to them a fair prospect of remuneration. The Board does not approve of a partnership in business between the Government and private firms. *All history warns against such a course.* But it does believe that joint, and at the same time independent, action between them can be made to work harmoniously towards the common national purpose. This can only be done by a permanent and liberal appropriation by Congress for the specific purpose of providing the country with modern artillery; which appropriation shall be a guarantee against loss to the companies who elect to undertake the work.

This is entirely consistent with the action of Congress in providing for the supply of arms to the militia. The act authorizing this practice was passed in 1808, and since that time the yearly disbursement has been made from the Treasury without interruption. A similar act providing for the supply of heavy ordnance for the regular services will be but a farther development of the same idea.

(3.) "The cost of all buildings, tools and implements, necessary to be used in the manufacture thereof, including the cost of a steam hammer or apparatus of sufficient size for the manufacture of the heaviest guns."

In reply to this question the Board presents an abstract of the information already given, arranged in a convenient form for reference.

Approximate cost of plant for producing the tempered parts of guns up to 100 tons, ready for delivery at gun factory:

Casting	$250,000
Forging (hydraulic press)	150,000
Rough boring and turning	210,000
Tempering	50,000
Total	660,000
Additional cost if liquid compression be adopted	175,000

Approximate cost of plant for gun factories:

Guns up to 6-inch caliber	50,000
Guns from 6-inch to 12-inch caliber	150,000
Guns from 12-inch to 16-inch caliber	350,000
Buildings and shrinking pit	350,000
Total	900,000

Three years will be required to complete the tools, construct the shops, and establish the plant. Such a factory will be able to turn out per year fifty 6-inch, seventeen 12-inch, and twelve 16-inch guns, or a proportionally larger number of smaller calibers, at a yearly expense of about $2,000,000. The figures cannot be pronounced exact, but the Board is confident that they closely approximate accuracy. The calculations are based upon estimates obtained abroad, and do not include ocean freight and customs dues.

Though the act of Congress replied to in the above report is one of inquiry, the Board desires to emphasize the necessity of a proper encouragement to the private steel manufacturers, which shall insure the supply of gun material without loss to the Government or private companies; and is of opinion if Congress shall be pleased to appropriate an adequte sum for providing modern artillery for the Army and Navy, to be held in the Treasury to be expended under the authority of the President, that (with such a prospect of remuneration) there are steel manufacturers in the United States who will undertake the production of gun-metal on a large scale, on the sole condition that their steel shall meet the required tests. Unless such action be taken, the Government will be compelled to purchase its gun-metal abroad, for it will be unreasonable to expect private parties to invest over half a million dollars in plant without a definite prospect for its employment.

The facts that the United States is destitute of the means of fabricating the modern guns so urgently needed for national defense, and that at least three years will be required to complete the tools, construct the shops, and establish the plant, would seem to demand an immediate appropriation of the amount ($1,800,000) estimated for the establishment of the proposed gun factories.

E. SIMPSON,
Rear-Admiral, United States Navy, President of the Board.
E. O. MATTHEWS,
Captain, United States Navy.
T. G. BAYLOR,
Colonel of Ordnance, United States Army.
HENRY L. ABBOT,
Lieutenant-Colonel of Engineers, Brevet Brigadier-General, United States Army.
SAM'L S. ELDER,
Major, Second Artillery, United States Army.
W. H. JAQUES,
Lieutenant, United States Navy, Member and Secretary of the Board.

ENGINES AND SHIPS.

The question as to engines, armor, and ships was briefly discussed in the following passage of the report of the Secretary of the Navy of December 1, 1883:

The question whether all the steel naval vessels of the future shall be constructed by contract, or some of them by contract and some in the navy-yards, it is not necessary immediately to determine. Assuming that the hulls of such ships might be

judiciously and economically built in the yards, it is doubtful whether the machinery will ever be so constructed. *All the engines for the British navy are built in private shops.* But conceding that, wherever the ships may be originally built, it is desirable for the Government to possess shops fitted for such repairs as may from time to time be found necessary, it is due to truth to declare that the Government repair shops under the present system ought not to be intrusted with them.

These establishments must first be thoroughly reorganized in such a way as to exclude all political considerations from their management, otherwise bad and expensive work will be the result. We cannot afford to destroy the speed of our naval engines in order to make votes for a political party. Whatever other governmental agency may be conducted with partisanship, a great naval workshop, dealing with the hull of a modern steel steamship, its fittings and equipment, and with the complexities of its machinery, cannot be successfully so managed. No charge of favoring private ship-building establishments should deter any one from asserting that, until the navy-yard workshops are managed on business principles and without regard to politics, the construction and repair of the new American Navy should be committed to those builders who employ or discharge their foremen and all their artisans according to their skill as mechanics and without caring for their political opinions or votes.

As an evidence of the expense attending the construction and repair of vessels in navy-yards, attention is also called to the letter of the Secretary of the Navy of January 11, 1884, transmitting, in compliance with a resolution of the Senate, a statement showing the original cost and cost of repairs of the vessels in existence, printed as Senate Ex. Doc. No. 48, Forty-eighth Congress, first session. (Inclosure I.)

It is only necessary to take a few instances to show how this policy of construction and repair in navy-yards has operated. The Shenandoah, built in 1862 at a cost of $463,866.75, has been charged with repairs since her completion amounting to $906,481.54. The Ossipee, built in 1861, cost $407,064.20, and her repairs since that time have amounted to $1,197,391.39. The Kearsarge, built in the same year for $286,918, has since been repaired at a cost of $1,123,415.75, or enough to have nearly built four new vessels of the same description. The Pinta, which cost in 1865 $135,915.91, has cost for repairs $224,826.52.

These figures are enough to show the startling results of the system of navy-yard labor, carried on under the supervision of Bureaus unrestricted by any limitations in the law, except the gross amount of their annual appropriations. They show that *instead of maintaining our navy-yards for the advantage and benefit of our ships, the ships have been dragging out a protracted existence for the benefit of the yards.* It is natural to expect that reforms will meet with strenuous opposition from those interests which have derived importance or benefit from the present system—the Bureaus, which are charged with the detailed expenditure of large appropriations of ill-defined application; the officials and employés, to whom a great navy-yard establishment gives a congenial though not too absorbing occupation; and the local interests, political or industrial, which might suffer from a withdrawal of navy-yard co-operation and support; but it is to be hoped that Congress will not be deterred by such influences from applying the necessary remedy, which has been frequently recommended by the Department.

The necessity thus expressed of fundamental reforms in methods of naval construction is considered vital. Any attempt to build new ships on the old system will be an expensive failure.

Very respectfully,

WILLIAM E. CHANDLER,
Secretary of the Navy.

Hon. JOSEPH R. HAWLEY,
Hon. SAMUEL J. RANDALL,
Chairmen Senate and House Committees on Ordnance and Naval Construction.

INCLOSURES.

A.—Report of Gun Foundry Board. (House Ex. Doc. 97, Forty-eighth Congress, first session.)
B.—"The Establishment of Steel Gun Factories in the United States," by Lieut. W. H. Jaques, United States Navy, member and secretary of the Gun Foundry Board.
C.—Circular letter of Gun Foundry Board to manufacturers.
D.—Letter of the Secretary of the Navy transmitting, in answer to a Senate resolution of March 20, 1884, copies of contracts for material for the iron-clad Miantonomoh. (Senate Ex. Doc. 144, Forty-eighth Congress, first session.)
E.—Correspondence between the Naval Advisory Board and steel manufacturers in reference to armor, including the Department's circular letter of June 20, 1884, and replies thereto.
F.—Circular for the information of steel manufacturers, July 8, 1884.
G.—Report of Navy-Yard Commission, December 1, 1883. (Senate Ex. Doc. 55, Forty-eighth Congress, first session.)
H.—Annual report of the Secretary of the Navy, December 1, 1883.
I.—Statement showing the cost of vessels built in navy-yards. (Senate Ex. Doc. 48, Forty-eighth Congress, first session.)

Inclosures A, B, D, F, G, H, I are transmitted as separate documents.
Inclosures C and E are printed herewith as follows:

C.

GUN FOUNDRY BOARD, NAVY DEPARTMENT,
Washington, D. C., May 15, 1884.

GENTLEMEN: There is forwarded to you herewith a copy of the report of the Gun Foundry Board, organized by order of the President April 2, 1883.

The report has been favorably received by Congress, and the Board is again in session for the purpose of supplying supplementary information looking towards the development of gun factories for the Army and the Navy.

In addition to what is contained in the report, your attention is particularly called to the following paragraph, included in the order under which the Board is now acting:

"In case the Board shall be of opinion that the manufacture of the necessary gun material should be developed in this country by contracts with American manufacturers the Board may communicate with and receive proposals from such manufacturers, and will cause to be prepared and submitted suitable contracts in detail, ready for execution, in case they shall be approved by Congress, and will make specific recommendations concerning the same."

The Board is also directed to report "in what annual installments appropriations can most conveniently be made."

You will see from the report that the Board is very decidedly of opinion that the gun material should be developed in this country, and the object of now addressing you is to request from you such proposals as may guide the Board in its recommendations as to the annual appropriations to be made. You are requested to consider the classes presented under the head of "Cost of plant for the manufacture of guns" on page 40 of the report.

There will be required for the largest guns a capacity for casting an ingot of 100 tons. For 12-inch and for 6-inch guns there will be required a capacity for casting ingots of about 30 tons and 5 tons, respectively.

For forging these masses there will be required a hydraulic press, with its accessories; for the largest castings one of 36-inch diameter will be necessary, but for the smaller ones presses of reduced power and cost may be substituted.

For rough boring and turning, there will be required a plant, as shown on page 41 of the report.

For tempering, there will be required a suitable furnace and tank.

All the above operations will be required at the foundry before the parts will be received at the gun factories, and estimates of the cost of the appliances are stated in the report.

In whatever particular your works may be deficient in the appliances required above, you are requested to consider the outlay necessary to efficiently equip your establishment, and to determine the size of contract for annual supply of gun material for a term of years, that will justify you in incurring this expense for plant, your remuneration to be derived solely from the price paid by the Government for the material after passing the tests required.

As this subject is now before Congress you are requested to provide the information asked for at your earliest convenience. In considering the matter of a plant for the manufacture of gun material the Board suggests that you do not lose sight of its availability for the manufacture of armor, for which a call may be made by the Government.

Very respectfully,

E. SIMPSON,
Rear-Admiral, U. S. Navy,
President of the Board.

E.

NAVAL ADVISORY BOARD, NAVY DEPARTMENT,
Washington City, July 11, 1884.

SIR: In accordance with the verbal order of the honorable Secretary of the Navy I have the honor to furnish copies of correspondence of the Department and this Board with the steel manufacturers of this country with reference to the manufacture of armor as follows:

1. Department's circular letter.
2. List of firms to whom this letter was addressed.
3. Copies of replies to Department's circular letter.
4. Copies of letters of this Board in answer to inquiries of steel makers.

Very respectfully,

E. SIMPSON,
Rear-Admiral, U. S. N., President of the Board.

Hon. W. E. CHANDLER, *Secretary of the Navy.*

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1. CIRCULAR.

NAVY DEPARTMENT,
Washington, June 20, 1884.

GENTLEMEN: The completion of the monitors Puritan, Amphitrite, Monadnock, and Terror will undoubtedly be authorized by Congress, and the Department is therefore desirous of obtaining early information pertaining to the armor-plates for the above vessels, and requests you to inform it whether or not you will be prepared to manufacture such armor or any portion thereof, and the earliest date after signing a contract at which you can deliver the same.

The amount of armor that will be required is about 3,000 tons, and it will be required in shape suited for side armor, turret-plates, smoke-pipe plates, and ventilator-plates. The thickness of the plates will vary from 6 to 17 inches, and a large number of them will be tapered in form. The other dimensions will vary from 15 feet to 24 feet in length and from 6 feet to 7 feet in width.

As it is desired that there shall be the freest competition, the specifications will admit bids for either all steel or compound armor, and this preliminary notice is given so that the Department may have the earliest notice of the probability of receiving bids from American manufacturers.

Each bidder will probably be required to submit with his bid a specimen plate 7½ feet square and of the maximum thickness which he proposes to furnish, which will be tested in open competition according to the method that may be prescribed for acceptance.

Letters of inquiry on this subject will be promptly answered.

WM. E. CHANDLER,
Secretary of the Navy.

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2. LIST OF STEEL WORKS TO WHICH THE CIRCULAR WAS SENT.

Nashua Iron and Steel Company, Nashua, N. H.
Bridgewater Iron Company, Bridgewater, Mass.
* Norway Steel and Iron Works.
Naylor & Co., 6 Oliver street, Boston, Mass.
* Albany and Rensselaer Iron and Steel Company, Troy, N. Y.
Newark Steel Works, Newark, N. J.
* New Jersey Steel and Iron Company, Trenton, N. J.
* Midvale Steel Company, Nicetown, Philadelphia, Pa.

* Replied.

Bethlehem Iron Works, Bethlehem, Pa.
Pennsylvania Steel Works, Steelton, Pa.
* Standard Steel Works, 220 South Fourth street, Philadelphia, Pa.
Black Diamond Steel Works.
Park Brothers & Co., Pittsburgh, Pa.
Edgar Thomson Steel Works, 48 Fifth avenue, Pittsburgh, Pa.
* Pittsburgh Steel Works, Pittsburgh, Pa.
Spang Steel and Iron Company, Limited, Pittsburgh, Pa.
Cambria Iron and Steel Works, Johnstown, Pa.
* Tredegar Iron and Steel Works, Richmond, Va.
* Cleveland Rolling Mill Company, Cleveland, Ohio.
* Otis Iron and Steel Works, Cleveland, Ohio.
Portsmouth Iron and Steel Works, Portsmouth, Ohio.
North Chicago Rolling Mill Company, Chicago, Ill.
* Springfield Iron Company's Iron and Steel Works, Springfield, Ill.

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3. REPLIES.

Norway Steel and Iron Company, 23 *Mason Building, Boston, June* 23, 1884.—"We have no means of rolling the armor plates referred to in your communication."

The Albany and Rensselaer Iron and Steel Company, Troy, N. Y., June 25, 1884.—"We regret that our plant lacks the proper facilities for turning out the material required, therefore are unable to submit samples for testing in competition with others."

The New Jersey Steel and Iron Company, Trenton N. J., June 21, 1884.—"Our machinery and plant is not adapted to the manufacture of armor plate of the dimensions described, and we could not advantageously undertake to manufacture."

The Midvale Steel Company, Philadelphia, June 24, 1884.—"We have received the Department's circular letter, dated June 20, 1884, covering an inquiry for armor plate for the monitors Amphitrite, Puritan, Monadnock, and Terror, contents of which have our careful attention. Will you be good enough to inform us as to the longest time which can be allowed for the delivery of the first plate? We desire to know this, because certain preparations would be necessary before we could undertake any such work."

The Standard Steel Works, 220 *South Fourth street, Philadelphia, Pa., June* 21, 1884.—"We are in receipt of your favor of the 20th instant, asking for bids on armor plate; but as we are not manufacturers of the article we shall be unable to comply with your request."

Anderson, DuPuy & Co., Pittsburgh Steel Works, Pittsburgh, Pa., June 27, 1884.—"We beg to acknowledge your favor of inquiry under date of June 20, with reference to armor plates. Replying thereto, we beg to say we are not prepared with our present machinery to handle the heavy plates necessary under this call. As the Department recently, we believe, purchased such plates, will you be kind enough to inform us of the approximate market charge made to our Government by the foreign manufacturers of this class of steel that we may better inform ourselves of the advisability of looking towards its manufacture? And, further, will you be kind enough to inform us as to the impression of our Government regarding the two kinds of plate, those of solid steel, like Messrs. Schneiders, or the compound plates as made by the English?"

The Tredegar Company, June 24, 1884.—"This company is not prepared to make armor plates of the dimensions you describe."

Cleveland Rolling Mill Company, Cleveland, Ohio, June 25, 1884.—"We have not the plant for rolling armor plate thick enough for the purpose named."

* Replied.

Otis Iron and Steel Company, Cleveland, Ohio, July 1, 1884.—"We are prepared to cast plates, up to 40 tons in weight, but cannot roll plates over 2 inches thick."

Springfield Iron Company, Springfield, Ill., July 18, 1884.—"I am sorry to have to say that we have no rolls at present heavy enough to make the kind of plates which you will require. Neither do we at present contemplate the erection of such a train of rolls."

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4. REPLIES TO QUESTIONS OF STEEL MANUFACTURERS.

NAVAL ADVISORY BOARD, NAVY DEPARTMENT,
Washington City, June 26, 1884.

MIDVALE STEEL COMPANY,
333 *Walnut street, Philadelphia:*

GENTLEMEN: Your letter of 24th instant relating to the supply of armor plates has been referred to this Board by the honorable Secretary of the Navy.

It is the opinion of the Board that four months from the date of the advertisement, which will be issued as soon as an appropriation is made, is the longest time which can be allowed for the delivery of the test plates.

Very respectfully,

E. SIMPSON,
Rear Admiral, U. S. N., President of the Board.

NAVAL ADVISORY BOARD, NAVY DEPARTMENT,
Washington City, July 1, 1884.

Messrs. ANDERSON, DUPUY & CO.,
Pittsburgh, Pa.:

DEAR SIRS: Your letter of 27th ultimo has been referred to this Board by the honorable Secretary of the Navy, and in reply we have the honor to forward a copy of the report of the Secretary of the Navy for 1883, in which, under the head of "armored vessels," you will find the prices paid for the turret armor of the Miantonomoh. Senate Ex. Doc., No. 144, also inclosed, gives further information on the subject.

The Department does not at this time express any preference for all steel or for compound armor.

If you deem this matter of sufficient interest to send a representative of your firm to Washington I shall be glad to furnish him with all information in my hands.

Very respectfully,

E. SIMPSON,
Rear Admiral, U. S. N., President of the Board.

NAVAL ADVISORY BOARD, NAVY DEPARTMENT,
Washington City, July 5, 1884.

OTIS IRON AND STEEL COMPANY,
Cleveland, Ohio:

Mr. J. K. BOLE:

DEAR SIR: Your letter of 1st July, in reply to the Department's circular of 20th ultimo, has been referred to this Board. Will you please inform the Board, in case proposals for armor are asked, whether you will submit a plate for test or not.

Very respectfully,

E. SIMPSON,
Rear Admiral, U. S. N., President of the Board.

NOTE.—No reply has been received to the last letter.

F.

[Circular to steel manufacturers.]

NAVY DEPARTMENT,
Washington, July 8, 1884.

The following is printed for the information of steel manufacturers.

WILLIAM E. CHANDLER,
Secretary of the Navy.

NAVY DEPARTMENT,
Washington, July 8, 1884.

SIR: Referring to the Circular Letter of the Navy Department to American steel manufacturers, relating to the manufacture of armor for the monitors, and with the object of providing information called for in the replies already received, I submit the following memoranda, which I recommend be communicated to those who show a desire to meet the needs of the Navy.

Very respectfully,

E. SIMPSON,
Rear-Admiral.

Hon. W. E. CHANDLER,
Secretary of the Navy.

CHARACTER OF ARMOR.

The Department is not prepared to decide between all steel and compound armor. The experiments abroad are not of so decided a character as to be indisputably accepted as establishing the superiority of either of the systems of manufacture. At the present time the manufacturer will have to decide for himself which system he will adopt, the firing tests being the same in all cases.

MODE OF MANUFACTURE.

The compound armor is manufactured in England under two patents, one of Mr. Ellis, manager of Sir John Brown & Co., and the other of Mr. Wilson, manager of Cammell & Co.

The method of manufacture of the back plate is common to the two establishments. The iron is taken in the puddled ball and rolled down to a plate 12 inches by 12 inches by 1 inch. Nine or ten of these are piled together, heated, hammered, and rolled to the same section (viz., 12 inches by 1 inch), and then cut into lengths of 2 feet 6 inches. Eighteen of these bars are piled into one furnace in three separate piles of six each. Each of these piles is then rolled, and then the three are piled together and rolled to 1 inch thickness and sheared to 6 feet by 5 feet; nine or ten of these plates are then piled together, heated, and rolled into a shape, which should be the width of the plate and about 3 inches thick. Six usually of these are piled together and rolled down to the thickness of the back plate required. The plate is then cut at the end.

At Sir John Brown's works the steel facing is formed of a steel plate, cast and forged, which is laid over the wrought-iron plate, the surfaces being kept apart by several rows of steel blocks (distance pieces) about 2 inches in diameter, placed 18 inches apart; the steel plate is also supported at the edges. The whole is then heated and transported to a vertical mold in a pit. One side of the mold consists of a movable plate which, after the insertion of the armor-plate, is forced up by a ram, thus holding all parts firm and preventing bulging of the face plate. The ladle with its charge of molten steel is then moved over the mold and the metal is run into the space between the plates, soldering them together. When taken from the mold the plate is heated and passed through the finishing rolls.

At the works of Messrs. Cammell the iron back plate, after heating, is placed in a mold which works on trunnions. After the plate is introduced the mold is turned to a vertical position and the steel poured, no steel face being previously prepared. As soon as the plate can be taken from the mold it is placed again in a furnace, and is then rolled down to its final thickness, in one heat, if possible.

Compound armor is manufactured by Cammell & Co., and by Sir John Brown & Co., Sheffield, England, and at the following establishments in France, under the Wilson patent:

Acierie de la Marine, St. Chamond; Marrel Frères, Rive de Gier; Chatillon et Commentry, Montluçon.

It is also made at the Direction du Dillingen Huttenwerke, Dillingen Saar Rhienprusse.

In the process described above it will be seen that the hammer is used during the early stages, but the chief portion of the *work* that is put into the metal is done by the rolls.

Estimating on the basis of the size of the plates required for the monitors, the manufacturer can form an idea of the size and capacity of the furnaces, cranes, rolls, &c., required for this work. These plates reach to 24 feet in length, 7 feet in width, and vary in thickness from 7 to 17 inches. Powerful presses are also required to bend the plates to the required shapes, and special planing-machines for fitting the plates.

With the exception of such amount of all steel armor as has been manufactured by Sir Joseph Whitworth for his own experiments, the manufacture of this material is limited to the works of Mr. H. Schneider, at Le Creusot, in France. In this manufacture it is recognized that the *work* required to be put into the metal cannot be communicated by the rolls, consequently, a heavy plant for *forging* is indispensable. The works at Le Creusot are equipped with the most powerful plant in the world for forging with hammers, hence they possess peculiar advantages for this kind of work. The following list presents the capacity of this establishment for forging purposes:

One 100-ton hammer, with a fall of 16.4 feet.
One 40-ton hammer, with a fall of 9.9 feet.
One 15-ton hammer, with a fall of 9.9 feet.
Two 10-ton hammers, with a fall of 8.2 feet.
One 8-ton hammer, with a fall of 8.2 feet.

The 100-ton hammer is the largest in the world. The anvil-block is constructed in six horizontal courses. Each course is formed of two castings, except the upper one, a single block, which weighs 120 tons and supports the anvil. Thus formed in 11 pieces, it is 18.4 feet high, 108 square feet at the base, and 23 square feet at the top. Its entire weight is 720 tons.

The foundations are composed of a mass of masonry laid in cement, resting on bed rock, which is found at a depth of 36 feet. Its upper surface is covered with a layer of oak about 3.3 feet in thickness, on which rests the anvil-block.

The legs of the frame are 33.6 feet in length, weighing 250 tons, and the entire height, from base of masonry foundation to the upper part of steam cylinder, is 102 feet. The cost of such a structure in the United States would probably reach a half million of dollars.

The ingots for armor are cast nearly cubical in form, with a head on one surface for the adjustment of the porter bar. A large allowance is made for sinking head—from 25 to 33 per cent. The ingot with porter bar in place is heated in a furnace near the hammer, and is handled by curved jib cranes, which have considerable capacity of spring, which enables them to yield to the effect of the shock of the hammer. An ingot of 75 tons is usually heated about eight times before being reduced to its final shape, after which the edges are cut off with powerful tools, some working as slotting machines, but others as *circular saws*, which cut through 18 inches of steel. The plates are tempered in oil, but the exact requirements of the subsequent tests are not known.

The two systems of manufacture are thus generally presented. A moderate capacity of forge combined with large rolls is sufficient for the manufacture of compound armor, but for steel powerful forging plant is necessary.

As there is now so much capital invested in hammers at Le Creusot, there is no probability of any attempt being made at that place to develop the work of forging by the hydraulic press, which has been so triumphantly applied by Sir Joseph Whitworth in his manufacture of steel for gun-tubes, but there can be no doubt that the press is equally applicable to forging armor-plates, and it is recommended to the American manufacturer to take this into serious consideration in embarking in this new industry.

The cost of a complete plant for the manufacture of compound armor would probably be as great as that for the manufacture of all steel armor, including a 100-ton hammer, but if the Whitworth hydraulic press be substituted for the large hammer there will be much economy in the adoption of steel armor. The question, then, to be decided is, can as good results be obtained with one as with the other.

COMPARATIVE TESTS OF ARMOR.

The following presents the results of some of the latest and most important competitive trials between steel and compound armor:

In 1880, a Cammell and a Schneider plate were tested at Gâvres by the French Government, with view to providing armor of the most perfect type for new armored vessels. The decision was in favor of the compound plate, but the report laid great stress on the possibilities of the development of steel, and in order to aid the Creusot works, a contract was made with Mr. Schneider for side armor for one of the ships.

When the selected armor plates were subsequently tested for reception, the steel plate proved to be superior to the compound plate.

In 1882, the Russian Government carried on a competitive trial between the Cammell and Schneider plates, at Ochta, near St. Petersburg. The result was decidedly in favor of the compound plate, but it was evident that the steel plate was not a fair sample of the manufacture, as its brittleness was apparent in its breaking up into several pieces.

In November, 1882, very famous trials were carried on at Spezzia by the Italian Government, in which the 100-ton gun was used against the plates. The contesting firms were Brown, Cammell, and Schneider. Each submitted a test plate of 10 feet 10 inches in length by 8 feet 7 inches wide by 18.9 inches thick. These plates were fired at with a projectile weighing 2,000 pounds, a charge of powder of 328 pounds, and a striking energy per inch of shot of 372 foot-tons. At the second round the Brown plate was split into six pieces, all of which except one were thrown from the target.

At the second round the Cammell plate was smashed and knocked completely off the target.

At the third round, a portion of the center of the Schneider plate was broken out, and the upper right quarter was displaced.

In this competition the steel plate had the decided advantage, having withstood the effect of the second round without having its capacity of protection destroyed.

Competitive trials have lately been made by the Danish Government on the island of Amager, a suburb of Copenhagen, where a firing-ground is established. The competitors on this occasion were four in number—Schneider, Brown, Cammell, and Marrel Frères—the latter submitting a compound plate manufactured under the Wilson patent, as in the case of the Cammell plate. The plates approximated to 9 inches in thickness, and were 4 feet 11 inches long by 6 feet 6 inches in width. The plates were bolted to a 9-inch oak backing, with skin plating and strengthening plates, and stiffened by angle-irons, and braced in rear by heavy oak balks.

The guns used were a 15 cent. Krupp and a 10-inch Armstrong muzzle-loader, using, respectively, a charge of 43 pounds, with a projectile of 112 pounds, and a charge of 69 pounds, with a projectile of 402 pounds. One shot was fired at each plate from the 15 cent. gun, the result being much the same in all cases so far as the shot was concerned, as it broke up, leaving the head sticking in the plates. The targets were all more or less cracked by this gun, the order of merit being: No. 1, Brown; No. 2, Cammell; No. 3, Schneider; No. 4, Marrel.

The first rounds from the 10-inch gun broke off the left half of the Schneider plate, and passed clear through the other plates, the order of merit being: No. 1, Brown; No. 2, Cammell; No. 3, Marrel; No. 4, Schneider. The failure of the Schneider plate was evidently due to brittleness.

Reviewing the competitive trails cited above, we may safely conclude that the want of consistency in the results of the trials is not due to any want of uniformity in the compound armor. This manufacture has reached a high point of perfection, and the plates are produced with certainty as to their characteristics.

Such imperfections as they exhibit are due to the system of manufacture, not to manipulation of separate plates, all of which exhibit a very uniform resistance to shot.

This has not been shown to be the case with all steel plates. The cases cited above show some instances in which the steel was superior and then again inferior to the compound armor, showing a want of uniformity in the results of the manufacture. The failures are always due to brittleness, but when this element is successfully suppressed the comparison is in favor of the steel plate. It would seem from this that the actual superiority of material rests with the steel, but that the problem of uniformity in manufacture is yet to be solved.

The question is a difficult one. The hardness of the steel is needed for the surface, but, if this characteristic be continued through the whole mass, brittleness will ensue; the effort must be made to combine a hard surface with a softer material behind it, but this must be achieved in one homogeneous mass. The development of this work is steadily progressing at Le Creusot, and the action of the French Government in ordering steel armor for four new ships indicates its confidence in the latest results.

It will thus be seen that it is impossible for the Navy Department to indicate, as has been requested in replies to a circular letter of the Secretary of the Navy, what may be its impression as to the relative advantages of either compound or all-steel armor. The question of selection must be decided by the manufacturer, and the Department must be guided by the results of the competitive trials.

Reports of tests, and detailed information as to foreign armor-plate manufacture, can be obtained by personal application at the Navy Department.

REPORT

OF THE

BRITISH COMMITTEE ON THE BUILDING AND REPAIR OF SHIPS.

[From the Report, presented to both Houses of Parliament by command of Her Majesty, of the committee appointed to inquire into the conditions under which contracts are invited for the building or repairing of ships, including their engines, for Her Majesty's Navy, and into the mode in which repairs and refits of ships are effected in Her Majesty's dock-yards. October, 1884.]

REPORT OF THE BRITISH COMMITTEE ON THE BUILDING AND REPAIR OF SHIPS.

The committee appointed by your lordships on the 24th April last "to inquire into the conditions under which contracts are invited for the building or repairing of ships, including their engines, for Her Majesty's navy, and into the mode in which repairs and refits of ships are effected in Her Majesty's dock-yards," have considered the matters referred to them, and after examining witnesses from the Admiralty, the royal dock-yards, and some of the leading private ship-building establishments of the kingdom, have agreed to the following report:

The order of reference above quoted divides itself into two main heads, the building and repairing of Her Majesty's ships under contract and the repairing and fitting of ships in Her Majesty's dock-yards, and though verbally limited in scope, really involves the important consideration of obtaining, under the best possible conditions, a navy possessing the highest efficiency in ships and armament.

I.—THE BUILDING AND REPAIRING OF HER MAJESTY'S SHIPS BY CONTRACT.

It appears to the committee that a comparison between the relative cost of a ship built in Her Majesty's dock-yards and under contract must necessarily to some extent be misleading.

The director of naval construction, in the course of his evidence, stated that the first cost of building a ship by contract was not, on the whole, in excess of that of building a similar ship in the dock-yard, excluding the "establishment charges." These charges, however, are an important factor in the estimate made by a contractor of the cost of the work he proposes to undertake. The comparison is further vitiated by the fact that the calculation and apportionment to each ship of the incidental or establishment charges is made on a system which does not show the entire cost of labor expended on a dock-yard built ship.

The evidence given by the accountant-general of the navy is sufficient to show that the whole question of incidental charges is so obscure as to render unreliable any comparison between the cost of ship-building in public and private yards. This evidence will be found in Paper No. 17 of the appendix, and on reference to it it will be seen that in 1882–'83 the incidental charges actually amounted to 44.5 per cent. upon the labor of ships built and repaired in the dock-yards, or 21.9 per cent. upon labor and materials united.

It has been represented to the committee by several witnesses that the incomplete and meager character of the specifications furnished by the admiralty to contractors not only increases the time during which ships are under construction, but also materially enhances the cost of the work, the contractors being under the necessity of framing their estimate without possessing full knowledge of the extent and details of the work they may be called upon to perform. The contractors, in conjunction with the admiralty, ought, in the opinion of the committee, to complete the specifications and the designs, so that the plans may be, as far as possible, agreed upon before the work is commenced. This opinion is strengthened by the evidence submitted that in the case of several ships of war which have been recently built in this country for foreign powers specifications and drawings have been so prepared as to enable the vessel to be completed without important changes, and in a reasonable time.

In connection with this point it may be stated that some complaints have been made of the supervision exercised over contract work by the Admiralty overseers. The interests of the public service, however, appear to demand that this supervision should be maintained, while as regards the mode in which it is exercised, cases of friction appear to be quite exceptional, and, in the main, the committee see no reason to doubt that the functions of the overseers are discharged discreetly and conscientiously. They are of opinion that arrangements might be made by which the contractors would be brought personally more in contact with the Admiralty, and the duties of the overseers more directed to an inspection of materials and workmanship, and thus avoid any friction that may arise under the present system. They would, however, point out that as the chief object of the supervision in question is to insure the details of the work being carried out according to the custom of Her Majesty's dock-yards, it would appear essential that the overseers should have more frequent opportunities of keeping themselves acquainted with those details.

As regards the quality of contract work as performed under Admiralty supervision, there appears to be no difference of opinion whatever, the unanimous testimony being that it is excellent, and in no way inferior to that performed in the dock-yards.

The time occupied in building a ship under contract compares favorably with the period of construction in a dock-yard, the whole tendency of contract work being to avoid delay. The progress of contract work is necessarily retarded by the vagueness of the specification, which, it has been suggested, is perhaps in some measure due to the desire to leave room for the introduction of any improvements or alterations in the fittings which may be considered desirable during the time the vessel is under construction. In connection with this point, the committee, while fully acknowledging the necessity of keeping ships of war abreast of the most modern improvements, are of opinion that it is desirable to discontinue the system of endeavoring to adapt every ship to the latest improvements, whether in gunnery or mechanical appliances, that may arise during the period she is under construction; that vessels when designed and laid down in the dock-yards or contracted for should be completed to receive the best armaments and mechanical inventions known to exist [when laid down *], and thus great expense would be avoided and time saved. It appears in evidence that in the case of ships built in the dock-yards at least three years out of six might be saved by this course, and the committee consider that the gain to the naval strength of the country by the more rapid completion of vessels possessing fittings of the most approved type at the time they were designed would more than counterbalance any advantage that might be gained by adopting the latest improvements, at the cost of serious delay, during the construction of the ship.

If this course was adopted, the principal, and, indeed, apparently the only, disadvantage under which contract building labors would be removed, and the area of such building might be extended, a result which would be attended by these advantages to the country, that not only would the resources of the dock-yards be rendered, to a greater extent than at present, available for repairs and for the building of ships of an experimental type, but familiarity with the art of building war ships would be spread throughout the country. Contractors would be encouraged by a more constant flow of work to provide themselves with

* Chairman.

the necessary skilled labor and costly plant, and facilities would thereby be afforded of increasing the naval defenses of the empire at a more rapid rate of progress than at present.

As regards the question of repairs, the case stands differently. On this point also the testimony is unanimous, and it is to the effect that the repair of Her Majesty's ships by contract is a costly and, unless under very exceptional circumstances, an undesirable course to adopt. The great difficulty of ascertaining the extent of the repairs before the ship is opened up renders it necessary, in the opinion of the Admiralty, for the work to be done under a schedule of prices. There is, however, abundant evidence that the system is an expensive one, and by transferring to the private trade a portion of the building it is anticipated that the whole of the repairs might be effected in the dock-yards, a course the adoption of which the committee would strongly recommend. These considerations naturally lead to the conclusion that it is expedient to extend the practice of building ships of war by contract, but at the same time it is obvious that a knowledge of Admiralty requirements, combined with practice in the execution of Government work, are essential to enable firms to frame their estimates with moderation and accuracy. The committee have it in evidence that undesirable results have attended the acceptance of inordinately low tenders made by firms not possessing the necessary experience, and while advocating the general extension of the practice of building by contract, they consider that regard should be paid to the character and experience of the firms who may submit offers, rather than to the apparent economy which might result from the acceptance of an estimate based upon an insufficient acquaintance with the requirements that will be exacted.

The committee, in making these recommendations, however, desire that it should be distinctly understood that they are averse to, in any way, diminishing the efficiency of the dock-yards. They consider it to be the utmost importance that a competent constructive staff should be maintained at these yards, and that sufficient building should be retained there to insure constant employment and perfect familiarity on the part not only of the constructors, but of the workmen, with the latest details of the most modern ships of war.

Strong evidence has been given to show that the great cause of the long delays that occur in the completion of iron-clad ships, and to a large extent of unarmored war vessels also, is the question of "armament." The substitution in recent years of heavy breech-loading guns for muzzle-loading ordnance, the changes in the mountings, carriages, slides, and gun fittings, the alteration of magazines, shot-racks, and shell-rooms, in consequence of the changes of shot, shell, and powder charges, the adoption of machine guns, and the introduction of torpedo gear and appliances, are changes which involve costly alterations in the structure of ships, and delay their completion not unfrequently for some years, owing to the difficulty which appears to be experienced in arriving at a decision.

It is also worthy of note that the Admiralty have been hitherto and are still exclusively employing one eminent firm in the north of England for all hydraulic mountings and loading appliances for the heavy guns of the navy. Your committee are however informed that the navy now take annually a vote of money specially for gun mountings, and is about to form a staff of designers of its own at the Admiralty.

Your committee are of opinion that this is a step in the right direction, and that the policy involved might with advantage be carried still further, nor can they see any good reason why the department, which

is responsible to the country for the ships and the maintenance of the fleet, should not undertake the entire responsibility of procuring the guns which the ships are to carry.

These considerations lead us to suggest:

1st. That the Admiralty should obtain the armaments they require, either through the ordnance department of the war office, or by direct contract with private firms as may from time to time appear desirable.

2d. That encouragement be given to the general engineering talent of the country to design, manufacture, and supply the carriage and hydraulic arrangements for working and loading the guns.

II.—Repairs and refits.

The term "repairs" is understood to mean the removal of defects in the hull or in the machinery of a ship, while by "refits" is understood the renewal, adjustment or alteration of fittings; ships in reserve on being brought forward for commission appear, as a rule, to undergo both repairs and refit.

The great expenditure which takes place in the dock-yards under these heads is stated in evidence to be due in a great measure to the stringent examination entailed upon the professional officers by the instructions, which were rendered much more rigid in consequence of the circumstances attending the loss of the iron transport Megæra, and partly to the nature of the supervision exercised by the captain of the steam reserve and his staff.

The rule usually, though by no means universally followed, appears to be this: A ship having completed her commission is ordered home and paid off into the fourth division of reserve, her rigging is stripped, masts taken out, stores landed, &c., so that when again brought forward for commission a considerable expenditure is necessary to put her back into the condition (which may have been a practically serviceable one) in which she was when paid off.

However necessary it may be that ships, after say two commissions in a hot climate, should undergo the most searching and thorough overhaul before being again sent to sea, such a course may not ordinarily be essential after a shorter period of service. The director of naval construction, in the course of his evidence, stated that ships with iron or steel frames now come home at the end of a commission in almost as perfect a condition as that in which they went out, notwithstanding which they are, on paying off, placed in the fourth division of reserve, and when again brought forward for commission the instructions require the dock-yard officers to give a certificate that there is nowhere a defect in them.

These observations apply no less to the unarmored than to the armored ships of Her Majesty's navy, and in connection with this point the committee would submit for consideration whether it is not possible to adopt at the home yards, to a larger extent than is now the case, the practice successfully carried out at Malta, Hong-Kong, Bermuda, &c., of paying off ships all standing and sending them out on a second commission after undergoing only such repairs as may be necessary to insure their fitness for the service on which they are to be employed.

While dealing with repairs and refits it appears to us that advantages would result from adopting in some cases a varied mode of paying off vessels, and that, where they had been employed only one (or perhaps two commissions) and are likely to be brought forward at an early date for recommission, they might not be relegated to the fourth-class reserve.

From evidence it appears that very considerable expense is incurred in preparing a ship for a new commission, which in many cases might be saved when her condition was such as to satisfy the dock-yard officers that she might be brought forward for service without that amount of "stripping" and "tearing up" which the dock-yard rules now require in the case of all ships brought forward from the fourth-class reserve.

Where this suggestion is intended to apply it is to be understood that it in no way contemplates relieving the Admiralty officers from their present responsibility that the ship when refitted shall be seaworthy and efficient. * * *

In concluding this report the committee desire to express an opinion that very careful consideration should be given before large expenditure is incurred upon structural repairs of Her Majesty's ships, especially those in the transport service.

The great improvements and economies effected in the design, construction, and machinery of ships of late years render vessels rapidly obsolete, and it appears to the committee that the practice prevailing in large mercantile companies of adding new ships to their fleet in preference to making large expenditure on old vessels is well worthy of the consideration of the Admiralty.

The committee desire to add that on the occasion of their visiting Chatham dock-yard it came to their notice that some of the tools employed in ship-building were of an obsolete character, which must necessarily increase the cost of the work, and they regret that want of time prevented them from visiting other of the home dock-yards.

RAVENSWORTH (*Chairman*).
DANL. GOOCH.
W. CODRINGTON.
C. M. NORWOOD.
CHAS. M. PALMER.
JOHN BURNS.
THOS. H. ISMAY.
JOSEPH D'A. SAMUDA.

FRANCIS H. MILLER,
Secretary.

MEMORANDUM APPENDED BY MR. SAMUDA.

I concur in this report so far as it goes, but in signing it I desire to annex observations and conclusions that I consider important to form part of it, and I desire them to be taken as a part of the conclusions I have arrived at.

(1) That a change in preparing specifications may with much advantage be introduced, and that great improvement would result from so preparing the specification before contracting for vessels as would practically reveal the work required to be done, and importantly reduce the number of clauses which at present are left without explanation and are reserved to be dictated to the contractor during the progress of the work by the overseer or to be submitted to and approved by him. This would practically leave to the builder the filling up of the details generally where not fully explained in the specification and submitting them for approval to the constructive department, and would confine the overseer to the duty of inspecting the quality of the work and materials, relieved from the greater authority he at present exercises as a director

of all the work, as well as an inspector of its quality, while the introduction of these changes in specifiying and in carrying out Admiralty contracts would result in a great saving of cost, and would enable the vessel to be completed in the contract time, which under the present system is not found to be practicable.

(2) That as regards the more important vessels—notably armor-clads—the building of those contracted for should be confined to such firms only as by reason of their extensive plant and means of executing the heaviest work, and through their previously great acquired experience, would be capable of lightening the work of the Admiralty constructors in dealing with the enormous amount of detail needed for carrying out such contracts, and could safely be intrusted to submit for their approval suitable arrangements for giving effect to the same, and then, due regard being taken to insure the work being contracted for at fair prices, such firms should be encouraged to expect, and should be kept supplied continuously as far as possible with, vessels of this important class, so as to keep their staff and establishment always available for these national works.

(3.) While as regards ships of less importance—cruisers, dispatch vessels, and smaller craft—the Admiralty list of contractors might with advantage be considerably enlarged; but even after doing so it would appear most desirable to confine it to houses of known experience and skill, and capable of assisting the Admiralty by bringing special knowledge to bear in completing the details from the Admiralty drawings to the approval of the constructors' department, and in whom sufficient confidence could be reposed to intrust them to give general effect to the same, so as to confine the overseer to the duty of inspecting the quality of the work and materials, relieved from the position of a director, as previously explained.

(4) A further national advantage would, in my opinion, be obtained by following more nearly in ship-building contracts, on suitable occasions, the course which appears to have been most successfully adopted in contracting for the engines of Her Majesty's navy—that is to say, by the Admiralty, in contracting for ships, supplying to those special and experienced firms a programme of the general features, powers, performances, guns to be carried, and coal endurance they desire to obtain, and availing themselves of such suggestions for giving effect to those conditions as the outside talent of the country can supply, and thus adding to the knowledge within the Admiralty that which exists without, and obtaining for the country the advantage of both in designing and constructing the national fleet.

This suggestion is not intended to convey application from the Admiralty for competitive designs, but to intrusting to any special and suitable firm, after having completed preliminary arrangements with it for the construction of the ship, the opportunity of submitting its own design to give effect to the Admiralty wants.

JOSEPH D'A. SAMUDA.

CONTRACT FOR HULL OF HER MAJESTY'S SHIP " ."*

It is Contracted and Agreed upon this day of in the year of our Lord one thousand eight hundred and between herein-after designated "the Contractors" of the one part and the Commissioners for executing the Office of Lord High Admiral of the United Kingdom of Great Britain and Ireland for and on behalf of Her Majesty Her Heirs and Successors hereinafter designated "the Commissioners" of the other part as follows that is to say—

1. The Contractors do hereby agree with the Commissioners that in consideration of the payments herein-after stipulated to be made to them the Contractors they will at by the one thousand eight hundred and to the satisfaction of the Commissioners and at their own cost risk and expense including dock dues and charges and in a proper and workmanlike manner and of the best materials and in conformity with the tracings and plans furnished to them and sanctioned by the Commissioners and to the specification hereunto annexed (marked A) build launch dock if necessary and float out of dock ready to receive her armament and in all respects complete as required by this contract a for Her Majesty's Service and deliver the same so complete as aforesaid and with the engines fixed on board safely afloat at any place in the port in which she is built that the Commissioners may direct into the charge of such person or persons as the Commissioners may appoint to receive the same but without prejudice to subsequent surveys and trials wherever the Commissioners may direct Provided always that such work as cannot be completed before the engines are put on board shall be completed by the Contractors without any extra charge for the same during the time the engines are being fixed.

2. And the Contractors do further agree with the Commissioners that the said vessel shall be built exceedingly strong and that the hull of the said vessel including the fittings of the hull and all internal arrangements of cabins store-rooms magazines shell-rooms and other fittings shall be entirely completed by them the Contractors.

3. And it is further agreed that the Commissioners and their officers shall have full power to declare before final payment is made whether the vessel is completed for sea in the terms of this Contract not only as regards materials and workmanship but also as to equipment (so far as required by this Contract on the part of the Contractors) And it is further agreed that no claim for extra work or for alterations of work deviations or omissions of any kind in the specification is to be made or allowed on any account whatever except the same shall have been

* Extract from the appendix of the report of the British committee on the building and repairs of ships, being the form used by the Board of Admiralty in contracting with a private party for the construction of a ship.

previously agreed to in writing and that no claim for any extra payment shall be made or allowed for or on account of the rejection of improper materials or of the reinstating of defective or improper workmanship.

4. And the Contractors do also covenant and agree that the said ship shall be launched and ready to receive her engines and machinery or if built in a dock shall be ready to receive her engines and machinery by the

5. And it is hereby further agreed by the Contractors and the Commissioners that the service and formalities usual in Her Majesty's Service shall be observed at the launch of this ship the officiating minister to be selected by the Commissioners and the Contractors hereby undertake to give timely notice to the Commissioners of the proposed date of launching in order that the Commissioners may select the Minister.

6. And the Contractors do further agree that the said vessel shall be placed after launching or floating out of dock in a berth where she cannot possibly touch the ground at any time of the tide while receiving her machinery or being completed such berth to be previously approved of by the Controller of the Navy for the time being.

7. And the Contractors do further agree to afford the Overseers who may from time to time be appointed by the Commissioners in connexion with the works to be performed under this Contract any assistance they may require in obtaining the weight of steel iron and other metal and the quantity of wood and other materials either in the ship or intended for her.

8. And it is hereby further agreed by the Contractors and the Commissioners that the several clauses articles powers provisoes matters and things mentioned and contained in the Specification hereunto annexed and in the drawings before mentioned referred to and not herein or hereby altered shall be as fully and effectually binding on the Contractors and the Commissioners respectively as if the same had been particularly repeated and expressed in the body of this present Contract Agreement.

9. And in consideration of the Contractors building completing and delivering the said vessel ready for sea within such specified time and at such place and in the manner aforesaid the Commissioners do hereby agree on behalf of Her Majesty Her Heirs and Successors that the Contractors shall be paid for the said vessel by bills on Her Majesty's Paymaster-General payable in three days from and after the respective dates thereof the sum of

pounds

and such sum is hereby declared and agreed to be the full compensation for the said vessel exclusive of her engines and complete as herein mentioned without any other charge expense or demand whatsoever and the said sum shall be paid in the manner at the times and in the instalments following or at such other times and in such other instalments as the Commissioners may think proper to direct that is to say—

10. And in case the Contractors shall fail or neglect to complete the said vessel in all respects as required by this Contract and in a fit state to be delivered into the charge of such person or persons as aforesaid on or before the said day of one thousand eight hundred and in accordance with this Contract then and in that case the price or sum agreed to be paid by the Commissioners for the

said vessel in clause 9 of this Contract shall be and the same is hereby varied as to amount and the same shall be and be taken to be lessened and diminished by the sum of

pounds daily and every day for each day which shall elapse between the day of one thousand eight hundred and and the day on which the said vessel shall be delivered into the charge of the person or persons aforesaid in accordance with this Contract

[If the engines for the said vessel shall not be delivered by their makers ready to be fixed on board by the

then provided that on or before that date the said vessel is ready to receive her engines and shall have been placed or offered to be placed by the Contractors in the hands of the makers of the engines to fix the same on board (the readiness or otherwise of the vessel to receive her engines as aforesaid to be determined by an Officer or Officers of the Commissioners appointed for the purpose) the lessening of the price specified in Clause 9 shall not commence to be made or take effect until the expiration of days (inclusive of Sundays and holidays) from the day on which the engines shall be delivered ready to be fixed as aforesaid Provided further and it is hereby declared and agreed that the amount of the said lessening of the price aforesaid if and when the same shall be made and take effect shall be taken from and deducted out of the final instalment mentioned in the said Clause 9].

11. And it is hereby further declared and agreed that in case at any time during the building of the said vessel any strike or stand-out of any of the workmen usually employed by the Contractors in building the same or in preparing the iron or other materials for the same shall take place and if in consequence thereof such workmen shall be absent from or refuse to work in and about the same and in case notice in writing of any such strike or stand-out shall be immediately given by the Contractors or their representatives to the Commissioners then and in such case so much further time shall be allowed for building and completing the said vessel as shall be necessary and proper to be allowed according to the time the said workmen or any of them shall be absent from or shall so refuse to work as aforesaid such time to be ascertained and decided by a reference to the Controller of the Navy for the time being whose decision thereupon is to be final and binding on all parties hereto and that such lessening of the sum agreed under

Clause 10 of this Contract to be paid by the Commissioners for the said vessel shall be calculated from such extended time.

12. And it is further agreed that the final payment above-mentioned that shall be due for the said vessel under this Contract shall be paid when the Officer or Officers of the Commissioners appointed to make the final survey shall have certified that she has been completed of good materials and workmanship and has been delivered safely afloat by the Contractors and that the whole of the works and materials heve been performed and finished in every respect according to the tenor of this Contract and to the specification and drawings but subject nevertheless to the provisoes contained in Clause 13 of this Contract and when the drawings by which the said vessel was built shall have been delivered up by the Contractors to the Department of the Controller of the Navy.

13. Provided nevertheless that should it be considered desirable by the Commissioners that any of the works required by this Contract to be performed and completed by the Contractors should not be so performed and completed by them or should any works be left by them in an unfinished state and the Commissioners shall be thereby compelled or shall choose to complete the same then in either or both of such cases the Overseer or Overseers is or are to furnish the Contractors with a list of such works and the said Overseer or Overseers and the Contractors shall together prepare an estimate in detail of the cost and expense of completing the said works and the estimate so prepared shall be submitted to the Controller of the Navy by the said Overseer or Overseers and if approved by him both in respect of the works and of the cost and expense of completing them the amount so arrived at or so much thereof as the said Controller of the Navy shall consider chargeable against the Contractors shall be deducted by the Commissioners from any money remaining to be paid to the Contractors under this or any other Contract or the amount of such cost and expense or any part thereof shall be a debt due to Her Majesty and be recoverable as such with full costs of suit And in the event of the said Overseer or Overseers and the Contractors not agreeing to the list of works to be considered as left unfinished under this Contract or to the estimated cost of completing such works the said Overseer or Overseers and the Contractors shall furnish to the Controller of the Navy separate lists in detail of such works as they respectively consider unfinished as aforesaid and estimates of the cost and expense of completing them in order that the Controller of the Navy may decide and determine thereon and the decision of the said Controller shall be final and binding on the Contractors and the Commissioners respectively and the terms of settlement shall be the same as herein-before specified Or the Commissioners may if they prefer so to do perform and complete the said works or any of them and the cost and expense of performing and completing them or any of them together with the charges incidental thereto shall be deducted or recovered by the Commissioners as and in manner aforesaid.

14. And the Contractors do further covenant promise contract and agree to and with the Commissioners that they the Contractors shall and will at their own proper costs and charges insure or cause to be insured in the joint names of the Commissioners and the Contractors the said vessel in some one or more of the most respectable offices in the United Kingdom of Great Britain and Ireland for insurance of buildings against fire to be approved of by the said Commissioners to such amount as hereinafter in that behalf expressed that is to say when the vessel shall be so far advanced or such materials provided as to entitle the Contractors to payment of the first instalment on the said vessel the said vessel shall

be insured for the full term of the Contract in an amount not less than the amount of the said first instalment and the Contractors shall and will previously to the payment to them of the said first instalment produce to and lodge with the Commissioners for the time being the policy or policies of insurance effected in that behalf and shall and will pay or cause to be paid the premium or premiums in respect of every such policy or policies from time to time until the said vessel shall be completed finished and delivered safely afloat ready for sea to Her Majesty's officers as herein-before mentioned and which policy or policies of insurance shall in the meantime remain with the Commissioners as a security (in case of fire) for the several sums of money which they shall have advanced to the Contractors for or on account of the building of the said vessel or of their Contract on that behalf And when and as the works of the said vessel shall be so far advanced as to entitle the Contractors to payment of any of the subsequent instalments and previously to receiving the respective bills for the amount thereof the Contractors shall and will insure the works of and the materials provided for the said vessel for the full term of the contract as aforesaid in the joint names and in manner aforesaid in the additional amount of every such instalment and previously to the payment of every such instalment produce to and lodge with the Commissioners the policy or policies effected in that behalf for the purpose before mentioned and pay or cause to be paid the several premiums of insurance in respect of such policies from time to time until the completion and delivery of the said vessel in manner herein-before mentioned Provided always that the total amount of the policy or policies of insurance effected in any one office and being in force at one and the same time shall not exceed fifty thousand pounds And if the Contractors at any time or times do not effect and keep in force any such insurance or insurances as aforesaid or do not produce to and lodge with the Commissioners any such policy or policies as aforesaid or do not pay any such premium or premiums as aforesaid then and in any or either of such cases it shall be lawful for but not imperative upon the Commissioners if and so long as they think fit to effect and keep in force any such insurance or insurances as aforesaid and to pay such premium and premiums as may be necessary for that purpose and the Contractors shall and will pay to Her Majesty's Paymaster-General the amount or amounts which may at any time or times be expended by or by the direction of the Commissioners for such purpose or the amount or amounts thereof may at the discretion of the Commissioners be deducted from any money which may at any time or times be or become due or payable to the Contractors under this or any other Contract And it is hereby agreed that in case the said vessel or any part thereof or the materials provided or any part thereof shall be destroyed or damaged by fire then the same shall at the costs and charges of the Contractors or by and out of the moneys to be received under or by virtue of such insurance or insurances with all possible speed be rebuilt or repaired and put in the same state and condition in every respect and with materials and workmanship of equal goodness as before the happening of such fire and the said materials reprovided without any charge or expense to the Commissioners or to Her Majesty Her Heirs and Successors.

15. And it is hereby covenanted and agreed by and between the said parties hereto that in case the said vessel or any part thereof or the materials provided or any part thereof shall happen to be destroyed or damaged by fire during the continuance of such insurance or insurances all such sum or sums of money as shall be receivable upon the policy or

policies so to be effected as aforesaid shall be paid into the hands of Her Majesty's Paymaster-General for the time being and be issued to the Contractors by bills payable in three days from and after the respective dates thereof by such instalments as the Commissioners for the time being shall think proper according to the progress made by the Contractors in rebuilding or repairing such vessel and in the reproviding of the said materials after the happening of such fire as aforesaid.

16. And it is hereby also covenanted and agreed by and between the said parties hereto that if the said Contractors shall fail in the performance of this Contract or shall neglect to carry on the work and complete the said vessel conformably to this Contract or shall become bankrupt or insolvent or make any conveyance or assignment of their or his estate and effects or any part thereof for the benefit of their or his creditors then and in such case or cases the said vessel or so much of the said vessel as shall have been constructed at the time of such failure or neglect and also all the works made and executed or in process of execution under this Contract and also such iron steel timber (whether converted or not) and other materials and things whether applicable or not to any purpose in the building of the said vessel and whether paid for or not as shall found in or about the premises where the said vessel shall be building or such part thereof as shall be approved by the Commissioners shall be the property of Her Majesty the Commissioners for the time being paying for such works as shall have been performed towards building the said vessel what the Controller of the Navy or such other person or persons as the Commissioners shall direct to survey and value the same shall certify them to be the amount of the value thereof with reference to the sum of pounds herein-before mentioned and agreed upon by and between the said parties and also paying for the said iron steel timber and other materials for the construction of the said vessel as aforesaid or as shall be found in or about the said premises such sum as the said Controller or such other person or persons as aforesaid shall certify to be the value thereof deducting from the total amount payable to the Contractors the amount of such Navy Bill or Bills as shall have been made out and delivered to them and also deducting therefrom the sum or sums of money by way of stipulated and ascertained damages herein-after referred to and also the value of any timber iron steel copper mixed metal and other articles which may have been supplied to the Contractors by Her Majesty but if the amount of the said Navy Bill or Bills and sum or sums aforesaid and value of the said timber iron steel copper mixed metal and other articles so supplied by Her Majesty shall be greater than the value of the said works iron steel timber and other materials and things at the time of the survey and valuation thereof above-mentioned then and in such case the Contractors do hereby covenant promise and agree to refund to the Commissioners all and every such sum and sums of money as they may have received upon account of the building of such vessel and for materials provided over and above the value at the time of such survey and valuation And that in case of such failure or neglect it shall and may be lawful to and for the Commissioners and such inspecting Officer or Officers as they shall appoint for that purpose to hire any workmen and others in the employ of the Contractors and with them or with any other workmen and others to enter into the yard or dock where the said vessel shall be building and either to take away the said vessel or employ workmen to finish the same in the said yard or dock and for that purpose to bring in all proper materials and do all things necessary for completing

the said vessel and for taking away the said vessel or for finishing her and shall also have the full and entire use of all the stages standards for stages shores and all articles appertaining to staging and shoring which shall have been put up or set up round or about the vessel or which may be found in or about the premises and the use of all plant steam power machinery tools and other articles and things provided by the Contractors and also to launch the said vessel for Her Majesty's use without any molestation or hindrance whatsoever from the Contractors their heirs executors administrators or assigns and without making any allowance or compensation by way of rent or otherwise for the use of the yard or dock and also without making any allowance or compensation by way of rent or otherwise for the use of the said stages standards for stages shores steam power plant machinery tools and other articles and things above expressed And in case of such failure or neglect as aforesaid it shall be lawful for the Commissioners if they see fit to have the benefit of any Contract or Contracts which the Contractors may have entered into for any materials for the construction of the said vessel or which may be applicable thereto and in such case the said materials shall be delivered by the parties with whom the Contractors may have agreed for the same to the Officers or Agents of the Commissioners the Commissioners in such case paying the amount to the said parties which the Contractors may have agreed to pay for such materials.

17. And the Contractors do hereby further agree that if any doubt should arise respecting the meaning of any part of the said several specifications or drawings the decision of the Controller of the Navy thereupon is to be final and binding and any omissions existing therein are to be supplied by him and that they the Contractors will comply with the part thus supplied by him without extra charge in the same manner as if it had formed part of the original specification or drawings (except the same shall have been previously agreed to in writing under the hand of the said Controller of the Navy) and that he (the Controller of the Navy) is to decide on being appealed to on matters of all kinds relating to the carrying out of this Contract about which there may be any dispute or difference of opinion between the Officer or Officers of the Commissioners and the Contractors and his (the said Controller of the Navy's) decision is to be final.

18. And it is hereby further agreed between and by the parties hereto that if any doubts disputes or differences shall arise between the Officers or Agents appointed to inspect the works herein contracted to be performed and the Contractors or between the Commissioners and the Contractors as to the meaning of this Contract or any part thereof or as to the liability or extent of the liability of the Contractors or the Commissioners under it or as to the amount payable to the Contractors or as to the time when the same is payable or as to the Contractors failing to perform this Contract or as to any other matter or thing in anywise relating to this Contract or incident thereto or to the construction and performance thereof such doubts disputes or differences shall from time to time be referred to and decided by the Controller for the time being of Her Majesty's Navy who shall be competent to enter on the subject matter of such doubts disputes or differences with or without formal reference or notice to the parties concerned or either of them and who shall decide and determine thereon and the order and award of the said Controller shall be final and binding on the Contractors and the Commissioners respectively And it shall not be competent for the Contractors or the Commissioners to except at law or in equity to any hearing or determi-

nation before or of the said Controller on the ground of any want of jurisdiction excess of authority or irregularity of proceeding or otherwise howsoever but all matters made the subject of any such hearing or determination or included in any order or award shall be held and deemed both at law and in equity to have been properly adjudicated And it shall not be competent for the Contractors to prefer or prosecute any petition of right or to maintain any action at law or suit in equity in respect of this Contract or any matter or thing arising under or out of it until the matters in dispute shall have been referred to and decided by the said Controller and then only for such sum if any as the Controller shall award And the obtaining the decision of the said Controller on the matters and claims in dispute is hereby declared to be a condition precedent to the right of the Contractors to prefer any such petition of right or to maintain any such action or suit.

19. And it is hereby further agreed by the Contractors that they the Contractors shall be responsible for the payment of and they hereby undertake to pay Patentees should there be any infringement of patent rights in the execution or performance of this Contract.

20. Provided always that in case at any time or times hereafter during the existence of this Contract the Office of Controller of the Navy shall be vacant then the Officer or Officers appointed by the Commissioners and fulfilling the duties or exercising the functions of such Controller of the Navy shall be and be deemed to be for the purposes of this Contract the Controller of the Navy and this Contract and the specification hereto annexed shall be read as if such Officer or Officers as aforesaid were in each paragraph and place substituted for and put in the place of the said Controller of the Navy as aforesaid.

21. And the Contractors do hereby agree that they will not without the consent in writing of the Commissioners assign or transfer this Contract.

22. And it is also agreed that in case of any Breach of this Contract on the part of the Contractors it shall be lawful for the Commissioners by writing under their hands or under the hand of their Secretary to determine this Contract without any previous notice to the Contractors nor shall they (the Contractors) be entitled to any compensation in consequence of such determination.

23. And in pursuance of the directions contained in a certain Act of Parliament made and passed in the twenty-second year of the reign of King George the Third intituled "An Act for restraining any person concerned in any Contract Commission or Agreement made for the Public Service from being elected or sitting and voting as a Member of the House of Commons" it is hereby expressly declared and agreed and these presents are upon this express condition that no Member of the House of Commons hath been or shall be admitted to any share or part of this Agreement or to any benefit to arise therefrom.

24. And lastly for the due and faithful performance of this Contract and every part thereof the Contractors do hereby bind themselves their heirs executors and administrators unto our Sovereign Lady the Queen in the sum of pounds of lawful British money to be paid to our said Lady the Queen Her Heirs and Successors by way of stipulated or ascertained damages agreed upon between the Commissioners and the Contractors over and above the amount of any other sum or sums which they the Contractors may have hereby rendered themselves liable to pay in case of any failure on their part in the due execution of this Contract or any part thereof.

In witness whereof the said parties to these Presents have hereunto set their hands the day and year first above written.

Signed Sealed and Delivered by the within-named

_____ _____

_____ _____

in the presence of

_____ _____

_____ _____

Signed Sealed and Delivered by the Commissioners in the presence of

_____ _____

_____ _____

OUTLINE SPECIFICATION FOR THE CONSTRUCTION OF MARINE ENGINES, AS USED BY THE BRITISH BOARD OF ADMIRALTY.*

A.

MACHINERY FOR THE _____

NOTE.—In tendering for the supply of these engines the Contractors are requested to forward a design and tender, in accordance with this specification and the drawing. They are also requested, if they have no objection, to forward a design and tender for any other plan of engines they may consider more suitable, observing that the machinery should be made as light as possible, consistent with strength, efficiency, and durability, and not exceeding the specified weight and keeping within the limits of space shown on the drawing.

In the preparation of the designs the following points are to be kept in view:—

1. The wing bulkheads in the boiler rooms are to be regarded as forming the inner skin of the ship.

2. The arrangement of the propeller shafting shown on the tracing is to be adhered to, so far as the ship is affected.

SPECIFICATION of certain Particulars to be *strictly* observed in the CONSTRUCTION of a Set of HORIZONTAL COMPOUND STEAM ENGINES and BOILERS, for the TWIN SCREW DESPATCH VESSEL.

ENGINES.

1. Each screw to be driven by an independent pair of engines of the collective power of 1,000 horses, giving an aggregate indicated power of 2,000 horses for both pairs of engines. The Contractors will be required to guarantee the development of this power for four consecutive hours at sea without the use of the steam blast or forced draught. A further trial of four hours duration is to be made under forced draught, during which it is expected that a power of 3,000 horses will be maintained.

2. The total weight of engines and boilers, including the water contained in them, and all other articles to be supplied under this contract, is not to exceed 360 tons.

3. The diameter of the high-pressure cylinders to be about 26 inches, and the diameter of the low-pressure cylinders to be not less than 50

* Extract from the appendix of the report of the British committee on the building and repairs of ships. October, 1884.

inches; the length of the stroke to be 2 feet 10 inches, and the number of revolutions to be about 110 per minute on the natural draught trial.

4. The high-pressure cylinders, their covers and bottoms, to be steam-jacketed with steam of boiler pressure; and the low-pressure cylinders, their covers and bottoms, to be steam-jacketed with steam of at least 50 lbs. pressure. The working barrels of all the cylinders to be made separately of Whitworth's fluid compressed steel. They are to be flanged and securely bolted to the cylinders with countersunk screws at one end, and fitted with an expansion joint at the other. The width of the steam space of the jackets to be not less than one inch. The branch pipes from the main steam pipe to the jackets of the low-pressure cylinders to be fitted with reducing valves of approved pattern and pressure gauges. The steam ports are to be stayed with iron or steel screwed stays where necessary, and all other parts are to be properly stayed.

5. The cylinder faces are to be made separately of hard close-grained cast iron or phosphor bronze, as may be ordered, and secured to the cylinders with a sufficient number of gun-metal screws with recessed heads.

6. The cylinders are to be fitted at each end with two 2½-inch escape valves, which are to be provided with springs long enough to permit of the opening required for the escape of water without undue increase of load, and to have suitable metal cases to prevent persons being scalded by any escape of boiling water. Suitable apparatus to be provided for taking indicator diagrams from each end of the cylinders. Cocks or valves for draining water from both ends of the cylinders, their jackets, and slide casings, and the receivers, are to be fitted. The pipes from the cylinders, low-pressure slide casings, and the receivers to be led into the condensers and bilge, all the others into the feed tanks and bilge. All drains are to be fitted so that they may be opened independently, and are to have non-return valves fitted in the pipes leading to the condensers and feed tanks. The valves on the cylinder jacket drains are to be conveniently situated to enable the flow of condensed steam to the feed tanks to be easily regulated. The cylinder drain cocks are to be fitted to be worked from the starting platforms. Manholes to be provided in the cylinders and their covers for getting at each side of the pistons. The receiver or pipe between the cylinders is to be fitted with a safety valve loaded to 60 lbs. per square inch, and a compound gauge.

7. All holding-down bolts for securing the engines in the ship are to be fitted with lock nuts or guards.

8. The slide-valves are to be double-ported, made of hard close-grained cast iron, planed up to a true surface, and fitted with packing rings on the back to relieve them of steam pressure. Double eccentrics to be used for working the slide valves, apparatus to be provided for fixing the links in any position, and the working parts to be made adjustable; the links and the valve rods to be of steel. Means to be provided for balancing the weight of the link motion. Other valves of approved construction in lieu of the ordinary slide valves may be fitted if desired. Adjustable links are to be fitted to the slide valve gears for working expansively. The slide valves to be fitted with efficient means for lubrication, both when the engines are at work and when standing.

9. Auxiliary engines with automatic stopping gear, as well as hand gear, to be fitted for working the slides; also auxiliary starting valves to all the cylinders to facilitate the handling of the engines. The levers

for these valves are to be so arranged as to work with the corresponding cranks, and to be placed in the same consecutive order as their respective cylinders. Arrangements are to be made for admitting steam direct to the receivers if necessary.

10. Wrought iron or steel to be used as far as may be considered practicable in the construction of the engine framework to economise weight.

11. The cylinders and their covers, slide valve casings and covers, and all hot surfaces, to be completely clothed with approved non-conducting material and mahogany, properly secured with polished brass straps.

12. The pistons are to be of approved construction, made of steel, and fitted with a single packing ring, held out by properly tempered steel springs. Solid blocks of length about one-fourth of the circumference of the piston are to be placed under the piston in lieu of springs. The junk ring nuts to be of gun metal, and the bolts to have secure guards.

13. The piston rods are to be made of wrought steel, and fitted with double glands. The surfaces of the piston-rod guides to be as large as possible, and the guides to be so fitted as to be capable of adjustment and to be efficiently lubricated. Gun-metal coned bushes are to be fitted at the bottoms of the stuffing boxes.

14. The gland nuts of all the principal rods throughout the engines and those of the stern tube glands are to be fitted with worm or toothed gear to enable all the nuts of each gland to be screwed up equally.

15. The connecting rods to be made of wrought steel, and the length between the centres to be not less than 5 feet 3 inches. The bearings to have wrought iron or steel caps, the brasses to be well supported and lined with white metal.

16. The crank shafts are to be made of Whitworth's fluid compressed steel or of Vicker's steel, and to be examined and approved by the Inspecting Officer before being fitted in place. The shafts to be made hollow, about 4 inches diameter inside, as may be determined. The diameter of the bearings to be not less than 10 inches, and the aggregate length of the bearings to be not less than 4 feet 3 inches. The diameter of the crank pins to be 10½ inches, and their length to be not less than 13 inches. The crank-shaft brasses to be lined with white metal, and so fitted that they may be taken out without necessitating the removal of the shaft. The crank pins to be fitted with centrifugal lubricators.

17. The propeller shafting is to be made hollow, of Whitworth's fluid compressed steel, and to have solid couplings where practicable. The diameter of the stern shafts to be not less than 9½ inches outside and about 4½ inches inside, exclusive of the casing. The thrust shafts and the length of shafting passing through the after part of engine room from the forward engines to be not less than 8½ inches diameter outside, and about 3½ inches inside. Each thrust shaft to have collars, giving a thrust surface of not less than 350 square inches. The thrust blocks to be fitted with movable collars so as to admit readily of adjustment. The plummer blocks to be of cast iron or steel, and lined with white metal. A bearing to be fitted as close to each thrust block as possible, so that the thrust bearings may carry no weight. The pieces of shafting between the stern tube and after bracket to be made of as large outside diameter as possible to give it the requisite stiffness.

18. Apparatus for turning the engines by hand, and for disconnecting and holding the propellers, to be provided. The disconnecting ap-

paratus to be of simple construction, and the bolts capable of being quickly removed and replaced.

19. All steel used throughout the engines is to be of quality approved by the Admiralty.

20. The tubes through the stern and after brackets to be made of gun-metal, not less than $\frac{7}{8}$-inch thick at the bearings, and the driving shafts within them to be cased with gun-metal of not less than $\frac{3}{4}$-inch in thickness at the bearings; each tube to be in one length, and if the casings of the shafts are in more than one length the several pieces are to be tightly filleted into each other so as to prevent leakage at the joints. A pipe and cock are to be fitted for drawing water from each stern tube. Lignum-vitæ strips to be used in both ends of the stern tubes and in the tubes through the outer brackets to form the bearing surfaces.

21. The screw propellers to be about 11 feet in diameter; they are to work outwards, and to be constructed on any principle and with any number of blades their Lordships may direct, and made of gun-metal of the following composition:—Copper 88, zinc 2, and tin 10 parts. The blades are to be attached to the bosses by means of screw bolts secured by proper guard plates and screws, and arranged to enable the pitch to be varied if required.

22. The surface condensers are to be made of gun-metal or of rolled brass containing not less than 70 per cent. of copper in its composition, and they are to be so arranged that the tubes may be readily packed at each end, and taken out without removing any part of the engines which cannot be removed and replaced with facility. Manholes are to be provided to admit of the interior of the condensers and the condition of the tubes being examined, and of the deposit being cleaned out from all parts. Cocks also to be fitted for the purpose of cleaning each condenser of the circulating water when the engines are stopped. Suitable pipe connexions with shut-off valves are to be made between the main steam pipes in the engine-room, and each condenser to be used as silent blow-off when the engines are suddenly eased or stopped. Fittings are to be provided for the purpose of admitting an alkaline solution into the exhaust passages. Directing plates are to be fitted to cause the circulating water to pass over the whole of the tube surfaces. No iron to be used in the internal fittings of the condenser. A compound gauge and an ordinary vacuum gauge to be fitted to each condenser. A small valve and pipe is also to be fitted to each condenser to admit water from the circulating chamber to the condenser or hot well to make up loss from leakages, &c.

23. The tubes to be of solid drawn brass, 0.05 inch in thickness, and to be tinned inside and outside. There must be at least 70 per cent. of best selected copper in their composition; and samples of them, of at least 4 lbs. weight, will be subjected to the same test and analysis as the brass boiler tubes. The tube plates to be of brass, and supporting diaphragms of brass to be fitted if necessary. The tubes are to be secured to the plates by screwed glands and tape packing, and approved means are to be adopted to prevent the tubes from slipping through the tube plates.

24. The number, diameter, and length of the tubes, and the total area of the cooling surface, to be stated in the Tender. The total area to be not less than 4,600 square feet.

25. The air-pumps are to be of gun-metal. The air-pump pistons to be of gun-metal, and fitted with efficient metal packing. The air-pump rods to be of gun-metal or of rolled naval brass, and the seats and guards of the foot and discharge valves to be of gun-metal.

26. Vulcanized india-rubber valves to be made of the best Para caoutchouc, with no other ingredients whatever than sulphur and white oxide of zinc; the sulphur not to exceed 3 per cent., and the oxide of zinc 70 per cent. The vulcanised india-rubber is not to contain any re-manufactured materials, but to be made of the best ingredients, to be of a homogeneous character throughout, thoroughly compressed, free from air-holes, pores, and all other imperfections. Samples of india-rubber are to be sent to Portsmouth to be tested, and must be capable of enduring a dry heat test of 270 degrees Fahrenheit for one hour, and a moist heat of 320 degrees Fahrenheit for three hours, without impairing its quality.

27. The circulating pumps with outer casings and fittings are to be made of gun-metal, and driven by independent engines. The proposed plan of engines and pumps to be submitted for approval. They are to be fitted with additional suction valves and pipes leading into the bilge, to be used for pumping water out of the ship in the event of a leak. The diameter of the bilge suctions is to be not less than that of the ordinary sea suctions to the pumps; and non-return valves are to be fitted at the lower ends of the bilge suction pipes, to prevent water passing into the ship when the sea suction is open. The bilge suction valves are to be placed in easily accessible places with their handles above the floor plates. The ends of the suction pipes are to be placed in convenient positions, as may be determined, and covered with zinced iron strainers. The circulating pump engines are to be supplied with steam from a branch on the main steam pipe, and to exhaust into the condensers as well as into the waste steam pipe. They are to be placed at as high a level as possible, and each circulating pump engine is to be made sufficiently powerful to discharge 400 tons of water per hour with steam of 60 lbs. pressure per square inch. Trial will be made to test the efficiency of the engines and pumps in this respect. The circulating engines and pumps are to be fitted in duplicate for each set of engines.

28. A screw-down non-return valve, with pipe leading from the bilge, is to be fitted to the bottom of each condenser.

29. A double cylinder engine of Admiralty pattern, with two double-acting pumps, is to be fitted in each boiler room for feeding the boilers. The suction pipes of these pumps to be fitted with stopcocks and connected with the feed tanks and the bottoms of the condensers. The diameter of each cylinder to be 6 inches and of each pump 4½ inches. Stroke 7 inches. A pressure gauge ranging up to twice the boiler pressure to be fitted on the delivery pipe from each of the feed pumps. A suitable air vessel and a screw-down non-return valve are to be fitted close to the pump in each delivery pipe. An air extractor of approved pattern is to be fitted in the main feed pipe. Separate delivery pipes with non-return stop-valves to be fitted for each boiler room.

30. Two feed tanks of wrought-iron not less than ¼-inch in thickness and each about 25 cubic feet capacity to be supplied and fitted with each set of engines as a reservoir for the feed water from the condenser. Two zinc blocks 12 inches by 6 inches by ½ inch thick to be suspended in each tank. A connecting pipe with a stop-cock to be fitted between the tanks. The tanks to be fitted with stop-cocks in the supply pipes, suitable overflow pipes, and glass gauges.

31. A double cylinder engine, of Admiralty pattern, with two double-acting pumps, is also to be fitted in each boiler room, connected with a set of feed pipes, feed valves, and overflow valves, separate and distinct from the pipes and apparatus belonging to the main feed pumps. The pumps

to be fitted to supply any of the boilers in both boiler rooms, and shut off valves are to be fitted in the auxiliary feed pipes to shut off communication of the forward and after boilers from the after and forward engines respectively. The diameter of the cylinders to be 6 inches, of the pumps 4½ inches. Stroke 7 inches. These pumps to be fitted to draw water from the feed tank and from the sea. Branch pipes are to be provided from the suction pipes of the forward pump for circulating water through the distilling condensers. Discharge connexions are also to be made with the nearest sea valve for use when the pump is employed for distilling purposes only.

32. A double cylinder engine, of Admiralty pattern, with two cylinders and two double-acting pumps, to be supplied and fitted with each set of engines for use as a fire engine, for washing decks, and pumping out the bilge and boilers. The diameter of each cylinder to be 6 inches, and of each pump 4½ inches. Stroke 7 inches. Each pump have separate suction and discharge pipes. A pressure gauge to be fitted to the delivery pipe of each pump.

33. All feed and bilge pumps, together with their valve boxes and fittings, to be of gun-metal. The bilge suctions of all pumps should be in the lowest part of the bilge, in positions approved by the Inspecting Officer.

34. All screw-down valves in connexion with the engines and boilers are to be so fitted that the valves will be closed with a right-hand motion. All steam admission valves to be be screw-down valves.

35. A hand pump, of 4 inches diameter, and 5 inches stroke, is to be fitted in the engine room and attached to the same feed pipes as the main feed pumps. This pump to be also arranged to pump water into the engine room, on the deck, or overboard, through a separate discharge pipe, and to draw water from the boilers, from the bilge and from the sea. To be also adapted by means of an additional plunger, 2½ inches in diameter, for proving the boilers by water pressure to double the working pressure.

36. Branches with nozzles, caps, and stop valves, to be fitted in the engine room to the hand pump, and the bilge engine discharge pipes to admit of hoses being attached. These branches, the nozzles on the deck, and all other nozzles, are to be made to fit the screws of the hoses used in Her Majesty's service, particulars of which will be supplied on application.

37. All steam pumps are to be fitted with escape valves. Non-return valves also to be fitted to guard against the danger arising from leaving open the sea cocks. All escape valves to be placed in positions easy of access, and so constructed that the valves and springs can be adjusted from the outside. All escape valve boxes, valves, and their casings (where required to be fitted) are to be of gun-metal. Pipes to be fitted to the escape valve boxes of the main and auxiliary feed engines to return the escaped water to the suction chambers.

38. The steam and all other pipes, as well as their branches, to be of copper or gun-metal, except where otherwise specified. All feed, bilge, blow-off, and brine pipes, not exceeding 5 inches diameter, to be of *solid drawn* copper. All the nozzles which pass through the ship's sides or bottom, and the sea-suction gratings, to be of gun-metal. The lower end of each bilge suction pipe to be of galvanised wrought iron, enamelled iron, or other improved material, and suitable strainers of the same material to be fitted to prevent choking. Care is to be taken that no copper or metal pipes in the bilge rest in contact with the hull work. All such pipes exposed to the action of the bilge water should be well painted

or varnished, and then covered with waterproof canvas. The flanges of all steam and other pipes to be faced, and the joints made with red-lead or wire gauze, and without canvas or millboard; those under the floor plates to be attached by gun-metal bolts and nuts. The aftermost lengths of each steam pipe to be fitted with a ring piece between the flanges to admit of a blank flange being inserted for testing the boilers and pipes independently of the engines; suitable blank flanges to be supplied.

39. A set of pipes to be provided complete, and fitted with a self-closing horizontal stop valve and an internal steam pipe on each of the boilers. These pipes to supply steam to the fan and auxiliary engines (except the circulating and main feed engines which are to be supplied from the main steam pipe), funnel blast, &c., and to be connected with the distilling condensers. The internal steam pipes to extend to the tops of the boilers to prevent water passing over to the distilling condensers when the vessel rolls. Stop valves to be fitted to the several branches in all positions considered necessary. All pipes which convey exhaust steam from the small engines to the waste pipes to be fitted with drain cocks. The exhaust steam from the fan, feed, circulating and other auxiliary engines to be delivered into the condenser as well as into the auxiliary waste steam pipe.

40. The thickness of the several pipes to be in accordance with the Admiralty scale drawing, a copy of which may be obtained on application. All bends and T-pieces to be respectively one gauge thicker than the plain pipes.

41. Expansion joints are to be fitted to the waste-water pipes, steam pipes, and to any other pipes where they may be considered necessary; and approved means to be adopted to prevent fracture by the contraction or expansion of any other parts of the machinery by the working of the ship.

42. All the steam and the eduction pipes, as well as the hot parts of the condensers, to be clothed with an approved non-conducting material to the satisfaction of the inspecting officer.

43. In the steam pipes leading to each high-pressure cylinder, and as close to the valve chest as possible, a double-seated equilibrium valve is to be fitted. These valves are to be fitted with gear leading to the platform to admit of being used to regulate the supply of steam to the engines. The valves and valve chest to be made of gun-metal.

44. A separator made of copper, to be fitted to each main steam pipe. The separators to be fitted to discharge into the sea and feed tanks. Each discharge pipe to be attached to a separate sea valve or to the nearest discharge valve, as may be determined, and to be fitted with a stop valve and non-return valve. A glass guage also to be fitted to each separator, and a small drain cock at the bottom to empty the separator when required.

45. Efficient self-acting discharge valves are to be fitted at the ship's sides to the air and circulating pumps' discharge pipes; the valve boxes are to be made of gun-metal, and non-return valves to be fitted to the extremities of all pipes discharging into them. Kingston's valves with the spindles cast on, or screw-down valves, with stop cocks or stop valves attached, are to be fitted close to the skin of the ship, to the blow-off pipes, and to the suction pipes of the circulating and other pumps, and to any other pipes considered necessary. All Kingston valve spindles are to be proved by a tensile strain of half a ton for every square inch of area of the valve, but in no case need the test exceed twelve tons. No waste water to be delivered above the steel deck. All

valves and cocks in connexion with the boilers or ship to have spigots passing through the plates. Only naval brass or gun-metal bolts to be used in connexion with all gun-metal under water fittings of the ship. Zinc protectors to be fitted at all the openings in the ship's skin for the under-water valves.

46. The handles to all cocks and valves in the engine department which open communication with the sea and bilge are to be placed at a convenient height above the platform, or flooring plates in their vicinity, in positions easily accessible by the engineer in charge, and above the level of the fire bars. They are to be so fitted that the valves will be closed by a right-hand motion, suitable means to be fitted for quickly changing from the sea to bilge suction when necessary. Suitable brass index plates are to be fitted to all the principal cocks and valves in the engine and boiler rooms.

47. An efficient governor of sufficient power to prevent the engines from racing in stormy weather, with properly balanced valves and all necessary connections, is to be fitted for each set of engines.

48. An engine room telegraph of approved pattern, with reply gongs and any number of dials that may be found necessary, to be supplied and fitted for each pair of engines.

49. A sufficient number of voice pipes of copper, not less than 0.036 inch in thickness, to be provided and fitted to put the engine room in communication with the boiler rooms, the bridge, the chief engineer's cabin, and any other part of the ship required. Each voice pipe is to be fitted with suitable mouth-pieces and whistles, and to be cased where necessary.

50. An eight-day clock of approved make to be supplied for the engine-room.

51. An efficient counter, capable of registering up to one million, is to be supplied for each pair of engines; also a tell-tale apparatus for each pair with an index on the bridge to show the speed of the engines and the direction in which they are moving.

52. Save-alls of copper or brass are to be fitted for all the working parts of the engines, and for the bearings of the screw shafting; the oil from the central parts of the engines to run into one large save-all for each set of engines, with a dish in the lower part. A suction pipe is to be led from each dish to a bilge engine, so that the contents may be pumped out while the engines are at work. Save-alls for trimming lamps and oil cans are also to be fitted as required.

53. A gun-metal plug, with india-rubber joint ring, is to be fitted to the mouth of each main discharge pipe, to be put in or taken out by means of a lever on the ship's side above the water line. The outriggers on the ship's side to be fitted complete with all levers and gear.

54. The high-pressure cylinders, covers, valve casings, the auxiliary engines, and all steam jackets, pipes, and connexions, valve boxes, impermeators, &c., subjected to the pressure of the boilers, are to be tested by water pressure to 160 lbs. on the square inch; the low-pressure cylinders, covers, and the intermediate receivers, to 100 lbs. on the square inch; the condensers where exposed to steam, to 30 lbs. on the sqnare inch; and the hot wells and all remaining parts to 15 lbs. on the square inch. The cylinders and condensers to be tested by water to the required pressure on the premises of the contractors, or before put on board, and so placed that all parts may be accessible for examination by the inspecting officer during the test. Each of the boiler and condenser tubes to be tested by water pressure separately, to 300 lbs. on the square inch, in the presence of the boiler overseer. No lagging or

covering of any kind is to be in place on the cylinders, pipes, or condensers during the water pressure tests.

BOILERS.

55. The boilers are to be constructed in general accordance with the arrangement shown on the tracing. They are to be made in four separate parts, any one of which may be used independently of the others, and they are to be capable of carrying steam of 100 lbs. pressure per square inch, and to be proved by water pressure to 200 lbs. per square inch. Steam is not to be raised in the boilers until after the usual water test on board unless desired for drying points, for which purpose the pressure must not exceed 10 lbs. per square inch.

56. There are to be 10 furnaces of the dimensions given on the drawing. The furnaces are to be made with stiffening rings on an improved plan, or they are to be corrugated if so ordered. The furnace frames and doors are to be made of wrought iron or steel, and so fitted that the doors can be kept open in a sea-way. The furnace bars to be of wrought-iron in three lengths, made and fitted in an approved manner.

57. Each boiler is to be fitted with a portable damper in the uptake, at least two safety valves, and two pressure guages of Admiralty pattern, one of which is to be graduated to 220 lbs. and the other to 120 lbs., provided with three-way cock and flange for application of test guage. A damper and a water trough for cooling ashes to be fitted to the front of every ashpit. External as well as internal plates are to be fixed to the smoke-box doors, which are also to be covered with silicate cotton one inch thick. Glass guages (two to each boiler), guage cocks, steam siren, and a fog whistle (not less than 6 inches diameter), are to fitted in accordance with Admiralty patterns, gear to be fitted to enable the whistle to be blown from the bridge. A small cock is to be fitted on the front of each boiler for drawing off water for testing its density and condition; this cock is also to be arranged to allow a syringe of Admiralty pattern to be screwed on for injecting mineral oil when necessary.

58. Two internal steam pipes to be fitted to extend the whole length of the boilers, and made with transverse slits through which the steam must pass. Internal feed pipes are also to be fitted. Zinc slabs, as required, are to be suspended in each boiler for the purpose of preventing corrosion.

59. The area of the tube surface between the tube plates is to be not less than 6,050 square feet, and the area of the fire grate to be not less than 226 square feet.

60. The boilers are to be constructed entirely of steel made by the Siemens-Martin process. The minimum thickness of the boiler plates to be as follows:—Shells, ends, and tube plates $\frac{5}{8}$-inch, furnaces and all other parts $\frac{1}{2}$-inch. The plates of the shells of the boilers to be double rivetted, except in the longitudinal seams, which are to be butt-jointed, with double butt straps and treble rivetted.

61. The plates and angle pieces for the shells, and the bar stays and tee pieces for securing the stays to the shells, are to be obtained from steel makers whose names are to be submitted for approval, and are to be subject to the usual tests for steel at the works of the manufacturer under the supervision of the Admiralty Overseer.

62. The tests are as follows:—

Strips cut lengthwise or crosswise to have an ultimate tensile strength of not less than 26 tons, and not exceeding 30 tons per square inch of

section, with an elongation of 20 per cent. in a length of 8 inches. The angle, tee, and bar steel to stand such forge tests, both hot and cold, as may be sufficient in the opinion of the Overseer to prove soundness of material and fitness for the service intended.

Strips cut lengthwise or crosswise 1½ inches wide, heated uniformly to a low cherry red, and cooled in water of 82 Farenheit, must stand bending double in a press to a curve of which the inner radius is one and a half times the thickness of the steel tested.

The strips are all to be cut in a planing machine, and to have the sharp edges taken off.

The ductility of every plate, angle, &c. is to be ascertained by the application of one or both of these tests to the shearing, or by bending them cold by the hammer.

All steel to be free from lamination and injurious surface defects.

The pieces of plate, angle, &c. cut out for testing are to be of parallel width for at least 8 inches of length.

63. The holes in the steel plates, angles, &c., are to be drilled and not punched. In parts where the rivets are not closed by the hydraulic riveting machine the rivet holes are to be countersunk and coned rivets used.

64. The tubes are to be of iron or steel of approved brand. They are to be not less than 2¾ inches in diameter, 0.180 inch mean thickness (4¾ lbs. weight per foot run), and not less than 1 inch apart. The stay tubes are to be not less than ¼-inch in thickness, and they are to be so fitted in the tube plates that they can be removed and replaced with facility. The ends of the stay tubes are to be thickened for screwing so that the thickness at the bottom of the thread is not less than ¼-inch.

65. In the manufacture of the boilers sufficient room is to be provided for man-holes at the upper parts and the lower parts of the furnaces, and below the tubes, both for the purpose of cleaning and repairing. All man-holes and mud-holes at the ends of the boilers to have stiffening rings. The doors to be of wrought-iron or steel, and to be placed on the inside of the boilers. The man-hole frames on the tops of the boilers to be raised about 6 inches, and the covers to be flat, secured with bolts and nuts.

66. The stays are to be arranged to admit of easy access to the internal parts of the boilers. The long stays to be secured to the shells of the boilers by tee-steels or in other approved manner; the rivets or bolts for securing the stays to be at least 25 per cent. stronger than the stays. Palm stays, if fitted, are to be forged from the solid and not welded. All short stays are to be screwed to a pitch of eight threads per inch. The screwed stays to be nutted on all flat surfaces. The maximum strain on the bar stays at the working pressure must not exceed 8,000 lbs. per square inch at the smallest section, and on the short screwed stays 6,000 lbs. per square inch at the bottom of the thread.

67. Surface blow-off as well as bottom blow-off apparatus to be fitted to each of the boilers, and the pipes to be so arranged that each boiler may be blown off separately. The blow-off sea cocks or valves to be fitted with guards and featherways, and the spanners to have corresponding feathers, so that they cannot be removed unless the cocks are shut. Screw-down valves are to be fitted on each boiler shell for the surface and bottom blow-offs.

68. Pipes, with suitable cocks or valves, fitted with hose connexions of Amiralty pattern to enable flexible hoses to be attached, are to be supplied and fitted for the purpose of filling the boilers of small steamboats with hot water from the main boilers, or to permit the water in

the boats' boilers to be boiled by the admission of steam, as may be determined.

69. Self-acting shut-off valves are to be fitted in the main steam pipes from the forward and after boiler rooms, so that in the event of either of the boiler-rooms becoming flooded or the steam pipes damaged, its steam connexion may be shut off, and the steam from the remaining boilers conveyed through the main steam pipe to the engines. An additional screw-down valve is to be fitted between these self-acting valves and the regulating valves at the engines. The main and auxilary steam pipes passing through the after boiler room to the engines to be well clothed with felt and water-proof canvas; the flanges to be clothed separately. The shut-off valves to be worked from the engine-room and deck.

70. The safety-valves are to be loaded with springs on an approved plan outside the boxes, and to be placed on the boilers independently of the internal steam pipes. A small supplementary test valve, about $\frac{3}{4}$-inch diameter, loaded with a spring to 5 lbs. above the working pressure, to be placed on the front of each boiler. A pipe connected to each safety-valve box to be provided for conveying the condensed steam to a tank which is to be placed in a convenient position. Gear to be fitted to enable the safety-valves to be relieved from the boiler-room floors and deck, the gear from both places to work independently of each other. All the joints of the safety-valve easing gear are to be bushed with gun-metal or fitted with gun-metal pins. Ferrules suitable for the reduction of pressure (by decrements of 5 lbs.) to 60 lbs. per square inch, to be supplied for all the valves. The springs to be so made that the amount of compression when screwed down to give the maximum working load shall be not less than one half the diameter of the valves. Provision also is to be made to prevent the valves being blown out in the event of the springs breaking. The area of the valves to be not less than 0.6 square inch per square foot of fire grate.

71. All feed, blow-off, stop, and safety-valves, and their boxes, and the boiler mountings generally, are to be made of gun-metal of the following composition: 90 parts copper, $2\frac{1}{2}$ zinc, and 10 tin. The main and auxiliary feed valves are to be constructed so that they can be regulated by a screw. The main feed valves are to be placed on the right-sides of the boilers, and the auxiliary feed valves on the left-sides. All valve boxes and covers are to be secured by outside flanges where practicable, or, if otherwise attached, care is to be taken that the bolts do not penetrate into steam or water spaces. Any internal apparatus for working the safety-valves is to be of gun-metal, and all pipes inside the boilers are to be of brass. Valves with fittings complete are to be provided for cleaning the tubes by a steam jet. All bolts which penetrate the shell of the boiler for securing the boiler mountings, lagging, or any other purpose, are where practicable, to be screwed through the plate with the bolt heads inside. Small cocks to be provided for effectually draining the steam pipes, stop-valve boxes, and whistle pipe. All valves and cocks in connexion with the boilers are to have spigots passing through the plates. Index plates are to be fitted on the fronts of the boilers at each gauge glass to indicate the positions of the tops of the combustion chambers or highest part of heating surface. An air cock is also to be fitted on the highest part of each boiler shell.

72. The main auxiliary stop valves on each boiler are to be made self-acting, of approved construction, and placed with the spindles horizontal. The main valves to have suitable index plates, and are to be so fitted that they can be closed from the boiler-room floors.

73. After the boilers have been proved, they are to be well painted with red lead; they are afterwards to be clothed in an approved manner on the barrels and ends with silicate cotton, or other approved non-combustile material, secured by steel angles, and covered, if considered necessary, with galvanized sheet-iron or steel $\frac{1}{16}$-inch thick. No combustible material is to be fitted in connexion with the clothing of the boilers. The spaces between the doors of the smoke boxes and their external plates are to be filled with silicate cotton. The fronts of the boilers to be clothed with silicate cotton and iron where considered necessary.

74. The boiler-room floor plates to be of wrought-iron, ribbed, and to be not less than $\frac{1}{4}$-inch in thickness.

75. The funnel is to be fixed, placed, and fitted as shown on the drawing. Tubes, casings, screens, and cowls are to be fitted by the Contractors. All the fittings necessary for securing the funnel are to be fitted complete. The funnel is to be made of $\frac{5}{16}$-inch steel plate, stiffened as may be required, and the casings are to be of steel plate 0.10 inch in thickness. A suitable cover for the top of the funnel to be supplied. The main waste-steam pipes from the safety-valves, and the auxiliary waste-steam pipes from the auxiliary engines, are to be taken up separately through the casings outside the funnel. The rake of the funnel to be as hereafter decided. The height of the funnels from the dead plates of the lower furnaces to be 55 feet.

76. A blast pipe 2 inches in diameter, with four nozzles each $\frac{1}{2}$-inch in diameter, is to be provided and fitted for the funnel.

77. All steam blowing fans, casings, and screens for maintaining the required air pressure in the stokeholds when working full power are to be included in the contract. The number and position of these fans and engines are shown on the drawings; the Contractors will be required to fit them complete with steam and exhaust pipes, &c., and they should be capable of maintaining an air pressure in the boiler rooms equal to a head of water of 3 inches.

78. Provision is to be made by the Contractors by means of air pipes and cowls on the upper deck for bringing down a sufficient supply of air to the stokeholds and furnaces when the boiler hatch shutters are open, and the engines are required to work at reduced power. The cowl heads of all ventilating tubes to be carried well above the bulwarks of the ship.

79. The boilers will be subject to the supervision of an overseer, who will be directed to attend on the premises of the Contractors during the progress of the work on the boilers, to examine the material and workmanship used in the construction, and to witness the prescribed tests. The extent of supervision is described on the attached paper extracted from Admiralty Instructions to Overseers.

GENERAL.

80. The air tube in the coal boxes for ascertaining their temperature are to be provided and fitted by the Contractors.

81. The top of the casings on the upper deck is to be fitted with gratings and movable covers, and openings (fitted with sliding doors) are to be made in the sides and after ends of the casings to permit the escape of hot air when the gratings on the top are covered in bad weather.

82. Rails or skids to be fitted throughout the lower coal boxes, if required, for trimming the coal, and a sufficient number of trucks and coal buckets to be provided.

83. Ash trunks and steam hoists complete, with four buckets to suit the ash trunks, are to be provided and fitted. All ash trunks to have the lower part made telescopic, so that it may be lowered to within 4 feet of the boiler room floors, and fitted so that they may be used when the stokeholes are under pressure.

84. Spare gear is to be provided as per list on page C, the several articles to be accurately fitted and tried in place to the satisfaction of the Inspecting Officer. The whole to be stowed on board the ship in convenient places, as may be arranged to suit the trim of the ship, and firmly secured by straps and bolts, or by any other means which may be considered necessary.

85. Tanks are to be supplied and fitted to hold the required quantity of oil, tallow, paint, oakum, india-rubber valves, and other Engineers' stores for six months' use. These tanks to be fixed in the Engineers' store-room, or elsewhere, as may be most convenient, with brackets, straps, and the necessary fastenings for securing them in place. The tanks not placed in the Engineers' store-room to be provided with locks or other means of securing them.

86. The glasses of the water gauges on the boilers, separators, feed tanks, and air extractors, to be $\frac{5}{8}$-inch external diameter. Those of the impermeators to be $\frac{7}{16}$-inch diameter. The glasses to be of Admiralty pattern, *i. e.*, with white enamelled strips.

87. All requisite lubricators and water service pipes for the engines and shafting, gauges fitted with lamps of Admiralty pattern, and brass covers, vessels for supplying the slide valves and cylinders with oil, and all necessary appliances for the ready removal of the cylinder covers, pistons, and other parts of the engines, are to be supplied and fitted by the Contractors, to the satisfaction of the Inspecting Officer. The Contractors are also to supply and fit in place the ladders, platforms, and floor plates required for the engine and boiler rooms, the fenders and guard rails for the engine rooms, the spanner racks in the engine rooms with a complete set of spanners, and the necessary racks for the stowage of the fire-irons in the boiler rooms.

88. The screw threads and dimensions of all ordinary bolts, nuts, and pins used in the engines and boilers, and in every other part of the work furnished by the Contractors, are to agree with Whitworth's standards. All iron bright nuts $\frac{1}{2}$-inch and under, to be case-hardened. Particulars of the following will, on application, be furnished to the Contractors, viz, Kingston's valves, engine room telegraphs, water gauges, sockets for indicators, fog whistle, pressure, compound, and vacuum gauges, cocks and valves, and all other small fittings, to which they will be required to conform.

89. Such parts of the engines, boilers, and other work supplied by the Contractors as are usually painted to have at least three coats of paint. The boilers are not to be painted until after they have been proved to the satisfaction of the Inspecting Officer.

90. Drawings, as per list on page D (with the exception of the last), are to be submitted before approval *before the work is taken in hand;* it is to be understood, however, that the approval of drawings will not exonerate the Contractors from any responsibility in connexion with the work.

91. The Contractors are not to introduce any contrivance which has not been tried and approved, without the express sanction of their Lordships.

92. The Contractors will have to provide the coal for such preliminary trials as they may have to make for testing the efficiency of the

machinery. They will also have to provide the coal for the official trials. Welsh coal only is to be used on the official trials. Mineral oil only, of approved quality, to be used in the cylinders and internal parts of the engines by the Contractors.

93. A preliminary trial of the engines under way will be necessary near the works of the Contractors, but the final trials of the machinery at sea are to take place from any one of Her Majesty's Dockyards that may be determined on, before the engines will be accepted by the Admiralty.

94. All charge of Navigation from the works of the Contractors to the Dockyard from which the final trials will be made will be borne by the Admiralty, but a representative of the Contractors will be expected to attend on board during the passage.

95. This Specification is intended to include the whole of the fittings in connexion with the engine department usual in ships of the Royal Navy; so that, with the exception of engineers' stores, the ship shall be in all respects, as regards the engine department, complete and ready for service at sea. It is therefore expressly to be understood that all minor fittings which may not be mentioned in the Specification, but which may be considered by the Inspecting Officers as requisite for the proper completion or the machinery, are to be provided by the Contractors without extra charge.

96. The Contract is to be executed in every respect to the satisfaction of the Controller of the Navy, who will, as he may see fit, appoint officers to inspect the machinery while it is being constructed on the premises of the Contractors, and being erected on board the ship.

97. The Contractors will be held responsible for the efficiency of the machinery for a period of twelve months after it has been accepted by the Admiralty, and any parts which during that period may be found defective or showing symptoms of weakness, owing to faulty design, materials, or workmanship, must be repaired, or removed and others substituted for them, by the Contractors at their own expense; or the Admiralty may, at their option, make such repairs and removals and charge the expense to the Contractors. The cost of making good any defects which may arise from fair wear and tear, or from improper management on the part of the engineers of the ship, will be borne by the Admiralty.

98. The engines to be delivered ready to be fixed on board the
at by the 188 .

Signature of the Parties tendering.

B.

TENDER from ..... for a set of Steam Engines and Boilers for the " ..... " pursuant to Specification accompanying the same.

N. B.—All the following particulars are to be carefully stated in this Paper, so far as may relate to the Tender required by the Admiralty.

Collected indicated power of the engines..... Horses

Weight of engines and shafting, as far aft as the after engine-room bulkhead, and all fittings, including the spare gear in the engine-room..... Tons — Centre of gravity to be marked on the drawing.

Weight of water in the surface condensers .....

Weight of screw propellers, stern fittings, and shafting, as far forward as the after engine-room bulkhead, and all fittings, including spare gear in the screw tunnels..... — Centre of gravity to be marked on the drawing.

Weight of boilers and funnels, casings, pipes, spare gear, and all fittings in the boiler rooms..

Weight of water in the boilers at a height of 9 inches above tops of tubes..... — Centre of gravity to be marked on the drawing.

Total Weight..... — Centre of gravity to be marked on the drawing.

Showing the position vertically as well as horizontally by figured dimensions.

Number of cylinders.....

Diameter of cylinders { High Pressure..... in. / Low Pressure..... in.

Length of stroke..... ft. in.

Intended number of revolutions per minute at full speed, at load draught of water..... No.

Cost of the engines, shafting, and propeller, also of the spare gear, and of all pipes and fittings connected with the engines..... — Including the erection and trial on board, the fitting and trying of the duplicate and spare articles whenever and wherever required, and all other items of expense relating to the engines mentioned in the Specification.

Cost of the boilers, and all mountings and fittings connected with the engines..... — Including the erection on board and all other items of expense relating to the boilers mentioned in the Specification.

Total Cost..... £

Date when the engines will be delivered complete, ready to be put on board.....

Further time required for fixing the whole in the vessel, so as to be fit for service..... — To be calculated from the date the ship is placed in the hands of the Contractors for this purpose.

At what place the engines are to be fixed on board

The construction of the engines is to be here fully described.

Particulars of Engines to be inserted as follows.

Piston Rods. Number to each cylinder.....
" Diameter .....
Connecting Rods. Diameter at middle.....
" " ends.....
" Length between centres .....
Crank Shaft Journals. Diameter.....
" Bearings. Total length.....
Crank Pins. Diameter.....
" Length .....
Propeller Shaft Journals. Diameter.....
Thrust Shaft Journals. Diameter .....
Stern Shaft. Diameter, within casing.....
Surface Condenser. Total cooling surface .....
" Tubes. Length between tube plates .....
" " External Diameter.....
" " Thickness, inches.....
" " Water inside or outside?.....
" Intermediate Tube Plates. Number .....
" Can Tubes be drawn without removing a portion of Coal Boxes, or any important part of the machinery?.....

Circulating Pumps.	Description	
"	Diameter	
	Stroke	
	Engine. Number of Cylinders	
	" Diameter of	
	" Stroke	
	" Estimated number of revolutions per minute	
Air Pumps.	Diameter	
"	Stroke	
"	Single or double acting	
Fan Engines for forced draught.	Number	
" "	Diameter of Cylinders	
" "	Stroke	
" "	Diameter of Fans	
" "	Revolutions at full power	
Main Steam Pipe.	Diameter	
" Feed "	"	
Each Blow-off Pipe	"	
Circulating Pump Suction Pipes.	Diameter	
" Discharge Pipes	"	
Bilge Injection "	" "	
Bilge Suction Pipes to Circulating Pumps.	Diameter	
Air Pump Discharge Pipes.	Diameter	

The construction and dimensions of the boilers, and the thickness of the plates of the various parts of them, the size of the fire grates, the number, length, and diameter of the tubes, and the size of the funnel to be here stated.

The whole to be made of the best materials, and the best workmanship employed.

Signature and address of parties tendering :—

———— ————.

———— ————.

Date of Tender ————.

C.

List of Spare Gear for Engines of 2,000 Indicated Horse Power.

SPARE GEAR.

	No.
Air Pump Connecting Rod	1
Air Pump Rod	1
Air Pump Cross Head (if so fitted)	1
Bars. Furnace for each Boiler	½ set
Bearers for one Furnace, for each Boiler	1 set
Blocks, Link, or Quadrant, for Slide Gear, for each set of Engines	1 set complete
Bolts and Nuts complete for one Screw Shaft Coupling	1 set
(If the coupling bolts or of different sizes or lengths ½ set of each size is to be supplied as spare.)	
Bolts and nuts turned and fitted for engines, properly assorted	240
Bolts and Nuts, assorted, for Boilers, sufficient to re-make the joints of the Doors.	
Brasses, Engine Shaft, Crank Pin (with bolts) and Pump Shaft, 1 set complete for each Circulating Pump and Engine.	
Brasses, Shaft and Crank Pin (with bolts) for main and auxiliary Feed (and Bilge) Engines of each size	1 set complete
Bushes (Gun-metal) for link motion (if so fitted)	1 for each joint
Collars, Gun-metal, Thrust (if so fitted)	1 set
Cylinder Cover of each kind (with Escape Valves), complete	1
Cylinder Cross Head, with Guide Blocks complete (if so fitted), of each kind	1
Eccentric Rod and Strap, of every size, complete, for Main and Circulating Engines, and also for Main and auxiliary Feed Engines.	1 each
Goose Neck for Deck Plate of Hand Pump and Fire Engines	1 each
High Pressure Cylinder Face, with Screws complete for each Engine	1

High Pressure Slide Valve, complete, for each Engine	1
Lignum-Vitæ Strips and Facings, for all parts so fitted	1 set
Piston and Rod of each size, complete	1
Propeller Blade, right and left handed, with Bolts, &c., for each Blade, complete	1 each
Rod, Connecting, complete	1
Rod, Slide, of each size, with Guide, Crosshead, and Nuts, complete, or in duplicate (if so fitted)	1
Screwed Stays for Boilers, $\frac{1}{16}$th inch larger than required when new, for one Boiler	1 set
Screws, Packing, for Slides, complete, for one set of Engines	1 set
Shackles for Propeller Blade	2
Spare Gear for Circulating Pumps	As required
Springs for each working Piston	1 set
Springs for other parts of Engines, for each set of Engines	1 set complete
Springs for Safety Valves, for one Boiler	2 sets
Stoppers and Bars for Tubes, $\frac{1}{10}$th the whole number of Stay Tubes fitted.	
Tubes, Stay, for Boilers, $\frac{1}{10}$th the whole number of Stay Tubes fitted.	
Tubes, Surface Condenser, Screw Glands for $\frac{1}{10}$th of the whole number fitted.	
Valves of Vulcanized India-Rubber, for each fitted in the Main and Auxiliary Engines	3
White Metal Bearings, Mandrils for	1 set

NOTE.—Such Articles contained in this List as are not to be found in the particular kind of Engine tendered for are to be struck out by the parties tendering, and any Articles added to it which, from the construction of the Engines and Propeller Machinery, may be considered necessary.

Signature of the parties tendering—

D.

DRAWINGS TO BE SUPPLIED.

NOTE.—All drawings to be made on *tracing cloth* and marked with figured dimensions. The quality and maker's name of all steel proposed to be used to be marked on the drawings.

1. A general arrangement of the machinery, embodying any modifications on the Tender which may be decided on, drawn to scale of not less than $\frac{1}{4}$-inch to the foot.

2. The engine, shaft, and boiler bearers shown fully for the guidance of the shipbuilders. This tracing to have indicated on it the positions of all holding-down bolts in connection with the machinery, and to be forwarded as soon as possible after approval of the general arrangement of the machinery.

3. Details of the boilers, to a scale of not less than 1 inch to the foot. This tracing to show the stays, joints of plates, mode of fitting tubes, furnace frames and doors, zinc blocks, man-holes and mud-holes, ash tubes, &c.

A duplicate tracing will also be required of the approved drawing for the use of the Boiler Overseer.

4. Details of cylinders, covers, pistons, and piston rods, showing fully the proposed manner of staying steam ports and other parts.

5. Details of slide, and starting valves, their seatings, jackets, rods, and all gear connected with them.

6. Arrangement of Kingston's valves, sea suction valves and cocks, and discharge valves, with the proposed method of attaching them to the skin of the ship.

7. Details of Kingston's sea suctions, discharge, and sluice valves to a scale of not less than ¼ size.

8. Crank shaft with coupling bolts, &c., complete, to scale of not less 1½ inch to the foot, also gear for turning and holding the engines.

9. Details of connecting rods.

10. Details of condenser, showing the manner of securing and packing tubes, &c.

11. Details of air pumps, showing valves, valve boxes, bilge injection, and all gear complete.

12. General arrangement and details of circulating engines and pumps, with all suction and delivery pipes and gear complete.

13. Details of eccentrics, straps, and rods, slide and starting gear complete.

14. Details of stern tubes and stern fittings complete.

15. Screw propeller. Full details of boss, blades, and method of attachment of blades, and feathering arrangement complete.

16. The proposed arrangement of funnel, casings, and all fittings for ventilation, also ash-hoisting gear.

17. Type and details of fan engines and fans with connexions.

18. Details of stop and safety-valves and their boxes, with all gear complete.

19. Details of regulating and shut-off valves, and their chests complete.

20. Arrangement of the main and auxiliary steam and exhaust pipes in the engine and boiler rooms, showing the position and number of expansion joints proposed to be fitted in them.

21. General arrangement (approximate) of all other pipes in engine and boiler rooms, with positions of auxiliary engines, hand pump, feed tank, &c.

22. Arrangement of main feed pipes with escapes, valves, &c., complete.

23. Pumping arrangements showing proposed positions of all bilge pumping engines and approximate positions of all suction and discharge pipes.

24. Separator and fittings in detail.

25. Engine framing and thrust block in detail; also thrust and propeller shafts.

26. Proposed arrangement of boiler mountings to scale of not less than 1½ inch to the foot.

27. Slide valve diagram showing setting of the slides and distribution of the steam.

28. General drawing of the machinery as fitted on board, to a scale of not less than ½-inch to the foot. This drawing is to be furnished after the completion of the work, and is to show the complete arrangement for ventilating engine and boiler rooms, the arrangement of pipes, cocks, and valves, and also the stern fittings.

NOTE.—The Contractors will be expected to supply any other detail drawings, in addition to those above enumerated, that may be required by the Admiralty.

Signature of the parties tendering—

FORM APPLICABLE TO SHIP BUILDING BY CONTRACT.*

CONDITIONS OF TENDERING FOR MARINE STEAM MACHINERY.

1. That the Tender shall be in accordance with the accompanying Tracing, Specification of Engines, List of Tools, &c., and upon the printed Form enclosed, every particular in which Form shall be *strictly* and *carefully* filled up.

2. That the Tender shall be delivered, together with a copy of the Specification, and of the List of Tools, &c., all duly dated and signed, at the Admiralty, Whitehall, not later than 2 p. m. on , in a sealed cover, addressed to the Secretary of the Admiralty, Ship Branch, and marked on the left-hand lower corner "Tender for Marine Engines," and that all drawings accompanying them shall be signed, and that all models accompanying them and the boxes containing them shall be distinctly marked with the names of the parties tendering.

3. That the whole weight of the engines (with the water in the surface condensers), boilers (with water in them), screw propellers, spare gear, floor plates, ladders, guard rails, and all other articles to be supplied under the Contract, shall be specified in the Tender.

4. Parties whose Tender shall be accepted undertake to execute the usual Contract, such as that exhibited, and to enter into the Bond required by the Contract in a round sum equal to about 25 per cent. of the total Contract price, binding them to the due and complete fulfilment of the Contract.

5. That it being considered of great importance that the weight should be accurately specified, a clause shall be inserted in the Contract to be entered into, binding the Contractor to submit to a reduction from the Contract price of three shillings for each specified Indicated Horse-power, if the actual weight shall exceed the estimated weight by 5 per cent., and a further reduction of two shillings for each specified Indicated Horse-power for every additional excess of one-half per cent. above 5 per cent.

6. That a clause shall also be inserted in the Contract to the effect that if the weight of the engines, boilers, &c., shall exceed by 10 per cent. the weight specified by the Contractors, the Lords Commissioners of the Admiralty may, if they think fit, reject the engines altogether, and the Contractors shall either supply new, or pay back all the money they have received on those rejected, as their Lordships may determine.

7. That the final instalment on the engines, &c., shall not be paid until the actual weight has been ascertained.

8. That a clause shall also be inserted in the Contract providing that if the engines, boilers, &c., shall be delivered by the Contractors at , ready to be fixed on board at an earlier date than , they shall be paid, in addition to the Contract price of the engines, &c., a premium of £ a day from the day of such delivery to the day of , and further that in case the engines, boilers, &c., shall be fixed by them on board the ship complete, and ready to set to work within a shorter period than days from the day on which the vessel shall be placed in their hands for the purpose of having the engines fixed on board, they shall be paid a further premium of £ a day for each day from the day on which the engines, &c., shall be fixed on board complete, and ready to

* Extract from the appendix of the report of the British committee on the building and repairs of ships. October, 1884.

set to work up to the expiration of the . days; but if on the other hand the engines, &c., are not delivered by the Contract time, a penalty of £ a-day shall be inflicted for each day's delay beyond the date fixed for delivery, and further that if the engines are not fixed on board by the time agreed upon, a similar penalty of £ for each day's delay shall be enforced for each day beyond the days allowed for that purpose.

9. That their Lordships do not bind themselves to accept the lowest or any Tender.

CONTRACTOR'S SPECIFICATION FOR A SHIP BUILT FOR A FOREIGN GOVERNMENT.*

TWIN ARMOUR-CLAD TURRET-SHIP "RIACHUELO," 5,685 tons (Displacement), as proposed to be built by Samuda Brothers, of Poplar, London, for the service of the Imperial Brazilian Government.

General Statement of Dimensions, Armament, Engines, &c., required, and Estimate of Weights.

DIMENSIONS.

Length between the perpendiculars	300 feet.
Breadth of Beam, extreme on water line	52 feet.
Depth from Garboard Strake to underside of Main Deck	22 feet 3 inches.
Draught of water, at load line	Not to exceed 20 feet.
Height of Port, above L. W. line	12 feet 2 inches.
Displacement, at load line	5,685 tons.
Do. per inch	31 tons.
Engines—Indicated horse power	6,000.
Estimated speed per hour, in knots, with 872 tons dead weight on board	15 knots.
Complement of Men and Officers	250.
Armament—Four 9-inch 20 tons Breech-loading Guns in two Revolving Turrets, and six 4½-inch ditto ditto, and two 7-pounder Guns, one on top of each turret.	
Height of Armour above L. W. L. on Breastwork	12 feet 6 inches.
" " on Belt	3 feet.
Depth below L. W. Line	4 feet.
Thickness of Armour on Belt	11, 10, and 7 inches.
" " on Breastwork	10 inches.
" " on Turrets	13 inches.
Deck plating—Main and Lower Decks	2 inches.
Deck over Breastwork	3 inches.
Thickness of Backing amidships	10 inches.

ESTIMATE OF WEIGHTS.

Hull of Vessels	1,760
Armour Plates and Fastening	1,120
Teak Backing	130
Deck-Plating on Main Deck and over Breastwork	350
Masts, Spars, Rigging, Blocks, and Sails	65
Anchors and Cables	75
Boats, Galleys, Condensers, &c	35
Wood and Metal Sheathing	169
	3,695

* Extract from the appendix of the report of the British committee on the building and repairs of ships. October, 1884.

Engines, Boilers, and Spare Gear			1,070
Armament Guns, Ammunition, Small Arms, Turret Engines, Hydraulic Apparatus, and other Gear supplied by Sir W. G. Armstrong and Co.	300		
Coal (Bunkers to contain 800 tons)	400		
Officers, Men, and Effects	32		872
Water for four weeks			
Provisions, Spirits, &c., for 12 weeks	140		
Officers' Stores, Slops, Wood, Sand, and Holystone			
Warrant Officers' and Engineers' Stores			
			5,637
Margin			48
			5,685

Displacement of vessel at load line, 5,685 tons.

SPECIFICATION.

Draught of Water.—The Contractor engages that the extreme draught of the ship in salt water when complete with all fittings, with machinery, boilers, and water on board, anchors, cables, masts, rigging, and sails in place, and a dead weight of 872 tons on board (consisting of or representing armament, ammunition, coal, and stores), shall not exceed 20 feet.

Speed.—And the mean speed so laden shall be 15 knots when tested at the Government measured mile at the Maplin Sands. The mean speed of the vessel to be based on six runs, and calculated from these runs on the Admiralty system.

Metacentric Height.—The vessel to be so designed and constructed that when loaded for sea she shall have a metacentric height above the centre of gravity of not less than 3 feet; and when lightened to any extent by the consumption of coal or stores, or by the removal of water from the boilers or condensers, she shall have at all the stages of lightening a metacentric height of not less than two and one-half feet.

The metacentric height shall be ascertained by an inclining experiment, as usual in ships for Her Majesty's Navy.

The Vessel.—To be constructed of steel, having two armour-plated turrets, each protected by an armour-plated breastwork, and each capable of carrying and working two of Armstrong's improved type 9-inch 20 tons breech-loading guns, and to be fitted for working six 4¾-inch guns on upper deck.

To have a water-line belt of armour for 250 feet amidships, extending from 4 feet below the water-line to the main deck, and inclined armour inside the vessel arranged so as to give great strength to the ram, and to complete the armour protection all fore and aft.

The armour plates to be worked on a teak backing, generally 8 to 11 inches thick, supported by topside plating 1 inch thick.

To be fitted to receive two pairs of marine compound surface condensing engines of the collective indicated power of 6,000 horses.

Principal Dimensions.

	Feet.	Inches.
Length between the perpendiculars	300	0
Breadth of beam, extreme on water line	52	0
Depth amidships from top of flat keel to underside of main deck	22	3

Vertical Centre Keel Plate.—36 inches deep and ½ inch thick in the double bottom. Before and abaft the double bottom the depth is to be

reduced by 4 inches, and to taper towards the stem and stern, as may be required. Plates to be 12 feet long.

The butts of the vertical keel plate are to be secured with double straps, one on each side, $\frac{5}{16}$ inch thick, to be treble riveted; their length to be $16\frac{1}{2}$ times the diameter of the rivets.

The flat keel plate is to be worked as shown on the Midship Section; the angle-bars connecting the vertical keel plate and the flat keel plate to be $4'' \times 4'' \times \frac{9}{16}''$.

The vertical centre keel plate to be caulked and made watertight, so that it may divide the double bottom into separate compartments.

Angle Bars on top of Vertical Keel.—To be $3'' \times 3'' \times \frac{3}{8}''$, worked in short lengths, with turned-down ends in the double bottom, before and abaft the double bottom, commencing from where the vertical keel is reduced in depth; these angle-bars are to be continuous.

Stern Framing.—To be of approved composition. It is necessary to keep the external breadth of the ship in way of the rudder head as small as possible, allowing sufficient room within. In order to do this it is proposed to house the ends of the wood sheathing before the rudder head, and form in a casting the side of the ship from the head of the post at the counter to the height of armour deck; also to include in the casting sufficient of the armour deck to admit of a good attachment of the protective plating, which will end here; the fore end of the casting is to form the angles for housing the ends of the sheathing. The Contractors are also to consider whether it would be desirable to make this part in one with the post, or to adopt one or more castings separate from the post.

Shaft Tubes.—Each to be formed of a brass tube for the reception ot the propeller shaft, to be in one thickness as the Overseer may direct, to be firmly supported at the after end by a brass crutch well secured to the hull of the ship.

The tube and crutches to be efficiently connected to the vessel. The ends of the tubes and near their junctions with the bottom may be of steel and sheathed like the bottom.

Stem.—To be a casting of approved composition, and to be carried as high as may be considered necessary. Above this, the stem is to be completed by an iron or steel forging, to be securely attached to the head of the casting. The horizontal plate of the ram is to be included in the casting, and care is to be taken that all available means are to be used to stiffen the stem in the way of the ram, and form a good attachment to the protective plating.

Longitudinal frames.	Plates Amidships.	Angle-bars.	
		Inner Edge.	Outer Edge.
No. 1, or armour shelf	$17'' \times \frac{1}{2}''$	$4'' \times 4'' \times \frac{1}{2}''$	$4'' \times 4'' \times \frac{1}{2}''$
" 2, longitudinal frame	$24'' \times \frac{5}{8}''$	$3'' \times 3'' \times \frac{5}{8}''$	$3'' \times 3'' \times \frac{5}{8}''$
" 3, " "	$24'' \times \frac{5}{8}''$	$3'' \times 3'' \times \frac{5}{8}''$	$3'' \times 3'' \times \frac{5}{8}''$
" 4, " "	$26'' \times \frac{5}{8}''$	$3'' \times 3'' + \frac{5}{8}''$	$3'' \times 3'' \times \frac{5}{8}''$
" 5, " "	$31'' \times \frac{5}{8}''$	$3'' \times 3'' \times \frac{5}{8}''$	$3'' \times 3'' \times \frac{5}{8}''$

The longitudinals are to be continuous, and are to taper at ends as may be required. Towards the ends of the vessel one of the longitudinals may be discontinued. Nos. 2, 3, 4, and 5 are to be scored over the angle bars on the outer edges of transverse frames, and are to be at-

tached to skin by short angle-bars. Also for the extent of the double bottom scores are to be made on the inner edges of Nos. 3, 4, and 5, to permit the reverse frames to pass through unbroken. For the extent of the double bottom No. 3 longitudinal is to be caulked and made watertight. Before and abaft the double bottom these longitudinals are to be decreased in depth on their inner edges to 4 inches less than the depth of the frames. Plates to be generally 18 feet long. The inner angle-bars on the longitudinals are to be worked in short lengths between the frames in the double bottom, but are to be continuous before and abaft it. The inner angle-bars of the 2nd longitudinal are to be continuous all fore and aft. The plates of the 2nd, 4th, and 5th longitudinals are to be pierced with holes between the frames in the double bottom, and as far forward and aft as may be desirable.

Care to be taken that the holes in adjacent longitudinals are so disposed as not to come in the same bay, nor yet be over a butt of the bottom plating, so that there may be, as far as possible, an uniformity of strength in each opening between the frames, and also that facility may be given for the proper survey of the vessel.

Transverse Frames behind Armour.—Behind the armour and on sides from one end of ship to the other, transverse frames are to be 2 feet apart, each to be formed of an angle-iron 8″ × 3″ × $\frac{7}{16}$″, with one angle-bar on the outside 3½″ × 3″ × $\frac{3}{8}$″. The alternate frames are to extend down to the longitudinal next below the armour shelf. The heels of these frames are supported by the ordinary frames in double bottom, which are 4 feet apart; the intermediate frames are to extend 2 feet below armour shelf, and are to be supported by short bracket plates 2 feet deep and $\frac{5}{16}$ inch thick, and angle-bars 3½″ × 3″ × $\frac{3}{8}$″ worked below the recess plate.

Transverse Frames in Double Bottom.—These frames are to be 4 feet apart throughout. They are to be composed of solid watertight frames about 20 feet apart and of intermediate bracket-frames, all $\frac{5}{16}$ inch thick of a continuous angle-bar 4″ × 3″ × $\frac{3}{8}$″ on outer edge, extending from armour shelf to keel, also of continuous angle-bar 3½″ × 3″ × $\frac{3}{8}$″ on inner edge, extending from No. 2 longitudinal on one side to No. 2 longitudinal on the other side.

The short angle-bars connecting the bracket-plates to the longitudinals to be 3″ × 3″ × $\frac{5}{16}$″.

Beneath the engine bearers solid plates $\frac{5}{16}$ inch thick, and lightened by means of holes, are to be substituted for the bracket-plates wherever necessary.

At the transverse bulkheads, where shown upon the drawings, solid frames forming thoroughly watertight divisions are to be fitted instead of bracket-frames.

Transverse Frames before and abaft the Double Bottom.—These frames are to be 4 feet apart; they are composed of $\frac{5}{16}$-inch plates of 4″ × 3″ × $\frac{3}{8}$″, continuous angle-bars on inner edge, of 4″ × 3″ × $\frac{3}{8}$″ angle-bar on outer edge, worked in one length from armour to keel, and, lastly, of short angle-bars 3″ × 3″ × $\frac{5}{16}$″ for connecting the plates to the longitudinals. The plates are to be in the form of brackets, as amidships, excepting at the water-tight bulkheads, where they are to be solid.

Transverse Frames above Armour Decks.—The transverse frames above armour-plated deck to be 4 feet apart, and are to be composed of 6″ × 3″ × $\frac{3}{8}$″ angle-bars and reverse angles 2½″ × 2½″ × $\frac{5}{16}$ with intermediate angles 3″ × 3″ × $\frac{3}{8}$″, to be turned at the heels and secured to deck plating, and having plate bracket in lower corner. These frames to extend to upper deck stringer.

Hammock Boxes.—To be composed of $\frac{3}{16}$″ plates, and angle-bars 2¼″ × 2¼″ × $\frac{3}{16}$″. Ample stowage to be provided for the normal complement of men, and also for a reasonable number of supernumeraries.

External Longitudinal Girders.—Longitudinal girders or frames, each formed of an angle-bar 8″ × 3½″ × $\frac{7}{16}$″ reduced where necessary to suit the backing, to be worked behind the armour-plates, and attached to the skin plating behind armour, as shown on the Section.

Inner Bottom Plating and Wing Passage.—A watertight bottom is to be wrought inside the ship, as shown on Midship Section, extending the whole length of engine and boiler rooms and magazines.

The plating on the floors to be ½ inch thick up to 3rd longitudinal vertical bulkhead or wing passage, lower strake $\frac{9}{16}$″, remainder $\frac{5}{16}$″. The plating to be worked with lap joints, single riveted at the edges, the plating on the floors to have the butts double chain riveted. The butts of the vertical bulkhead to be lapped and single riveted. The whole to be caulked and made watertight, to be arranged with necessary manholes, which are to have watertight covers.

Outside Plating.—To be wrought as shown on the Midship Section.

The bottom plating is to be worked with lap joints from keel to armour shelf; the plating behind armour, as also the whole of the topside plating, is to be worked flush jointed. The plates are to be generally in lengths of 12 feet, and there are to be two plates between butts vertically over each other.

The thickness of the plates to be as follows:—

Name of Strake.	Amidships.	Forward and Aft.
	in.	in.
Middle line, or keel strake	½	½
The remainder to armour shelf	½	½
In wake of belt	Two thicknesses, each ½.	—
Sides of breastworks	Two thicknesses, each ½.	—
Topside plating	$\frac{7}{16}$	$\frac{7}{16}$
Berthing above upper deck	—	$\frac{7}{16}$ with $\frac{9}{16}$″ plates in way of fire of guns.

The plating ending on the post is to be double riveted to it. The edges of bottom plates to be single riveted, and butts to be double chain riveted. The butt straps to the bottom plates are to be the same thickness as the plates they connect, those to the inside strakes are to be the whole breadth of the plates, those to the outer strakes to be carefully fitted between the edges of the inside strakes adjacent; all butt straps are to have the fibre in the same direction as the plate.

The edges of the plates above armour belt are to have edge strips and butt straps worked on the inside, the edge strips to be single riveted, and the butt straps double riveted.

The edges and butts of the plating behind armour are not to have strips or straps, but each thickness of plating is to be riveted to the other thickness along the edges and at the butts with single rows of rivets, thereby making one thickness answer the purpose of edge strips and butt straps for the other. The edges of the plates are to be so arranged that the edge fastenings may work in for fastening the external girders as far as possible.

Solid liners of the same thickness as the adjacent plates are to be fitted between the frames and the outside strakes of the bottom plat-

ing; the liners at the bulkheads are to extend on each side of the angle-bars of the frame, so as to take two additional rows of rivets on each side.

Transverse Watertight Bulkheads.—To be placed as shown on drawings, and to be bounded throughout the length of the double bottom by the inner bottom, not passing through it. The bulkheads before and abaft the double bottom to lap on the frames, and to be single riveted to them. All these bulkheads are to be lap jointed, lap butted, single riveted, and supported by angle-bars $3\frac{1}{2}'' \times 3'' \times \frac{3}{8}''$ placed vertically 30 inches apart.

Plates lower strake $\frac{3}{8}$ inch, remainder $\frac{5}{16}$ and $\frac{1}{2}''$ thick.

Middle Line Bulkhead in Engine and Boiler Room.—Of $\frac{1}{2}$-inch plates with lower strakes $\frac{3}{8}$, stiffened with angle-bars $4'' \times 3'' \times \frac{3}{8}''$, spaced 4 feet apart, with $3'' \times 3'' \times \frac{3}{8}''$ intermediate stiffeners.

Shaft Passages.—The shaft passages are to be formed as shown on the drawings with plates $\frac{1}{2}$ inch thick, the lower strake being $\frac{3}{8}$ inch thick, supported by angle-bars $3'' \times 3'' \times \frac{5}{16}''$, placed 2 feet apart.

Engine, Boiler, and Shaft Bearers.—To be fitted in accordance with the requirements of the engines. The necessary strengthening to be worked beneath inner bottom by means of solid web plates as previously described.

Deck Beams.—Flying deck beams to be 6-inch tee bulb, spaced every 4 feet apart.

Upper deck beams of 9-inch tee bulb, spaced every 4 feet apart.

Main deck beams to be of 9-inch tee bulb under the 2-inch plating, and 8-inch tee bulb before and abaft, spaced 4 feet apart. The half beams and the shorter beams towards the ends of the vessel to be 8-inch tee bulb.

Beams under turrets to be formed of plates and angle-bars.

Lower deck beams to be 8-inch tee bulb, spaced 4 feet apart.

Platform deck beams $5'' \times 3\frac{1}{2}'' \times \frac{3}{8}''$ angle bulb, spaced generally 4 feet apart.

Beams and half beams to have welded ends. The depth of the ends to be generally two and a half times the depth of the respective beams.

Stringer on Flying Deck.—Stringer on flying deck of plates 21 inches wide $\times \frac{5}{16}$ inch thick increased in way of explosion of guns.

Stringer on Upper Deck Beams.—The whole of the surface outside the flying deck to be covered with steel plates generally $\frac{3}{8}$ inch thick, increased in way of explosion of guns to $\frac{5}{8}$ inch thick. Forward and aft to be 36 inches wide by $\frac{5}{16}$ inch thick.

Stringer on Main Deck Beams.—Forward and aft of armour deck to be $36'' \times \frac{1}{2}''$, angle-bars $3'' \times 3'' \times \frac{3}{8}''$.

Coamings of Engine and Boiler Hatchways.—To be formed of $\frac{3}{8}$-inch plate attached to deck beams or deck plating by $3\frac{1}{2}'' \times 3'' \times \frac{3}{8}''$.

Pillars.—Generally to be wrought-iron tubes, with heads and heels welded in solid, and firmly secured to beams, to be placed where necessary:—

	in.	in.
Under main deck amidships	5	× $\frac{1}{2}$
On battery deck	4	× $\frac{1}{2}$
On main deck	4	× $\frac{5}{16}$

Solid pillars may be substituted in way of cabins if thought desirable. Any special supports that may be necessary under the heavy guns are to be provided by the Contractor to the satisfaction of the Overseer.

Chain Lockers.—To be built where shown on the drawings, to be formed of plates $\frac{1}{4}$ inch thick, stiffened with angle-bars $3'' \times 2\frac{1}{2}'' \times \frac{3}{8}''$, placed vertically, about 2 feet apart.

Weight of Vessel.—More than usual care is to observed to keep the weight of all steel used in the vessel within the estimate, and in order to ensure this the weight is not, on any account, to exceed that due to the scantlings specified, or fall more than 5 per cent. below it in any case, except where the thickness of plates and angle-bars is below ½ inch in thickness, and then 10 per cent. instead of 5 per cent. reduction will be allowed.

Quality of Materials.—Hull to be built of steel of the quality used by the Admiralty for shipbuilding, and the material is to stand the Admiralty tests, viz., strips cut lengthwise or crosswise to have an ultimate tensile strength of not less than 26 and not exceeding 30 tons per square inch of section, with an elongation of 20 per cent. in a length of 8 inches. The beam, angle, bulb, and bar steel to stand such forge tests, both hot and cold, as may be sufficient to prove soundness of material and fitness for the service.

Strips, cut crosswise or lengthwise, 1½ inch wide, heated uniformly to a low cherry red, and cooled in water of 82° Fahrenheit, must stand bending in a press to a curve of which the inner radius is one and a half times the thickness of the steel tested.

A shearing is to be taken from every plate, and piece from every bar, to be tested by the Overseer whenever required.

All steel to be free from lamination and injurious surface defects.

The Contractor to provide facilities for testing, and bear the expense of tests made.

Where angle-bars are to be welded up for watertight work they may be of iron of superior quality.

All rivets are to be made of steel of the very best quality. All rivets above ⅝-inch diameter to be made of conical form under the head, except where the holes have been drilled.

The riveting is to be executed in a careful manner, the rivets thoroughly filling the holes. The greatest care is to be taken to prevent unfair holes, and all such holes are to be rimed out before riveting.

The treatment of steel bars and plates to be that adopted by the Admiralty. Plates and bars to be worked cold if possible; if not, they are to be heated over as little length as possible, and after bending are to be annealed over the heated parts. Holes in outside plating to be punched ⅛ inch less in diameter than the diameter of the rivets used, the holes to be countersunk right through the plating to the required size.

Vertical Armour on Sides of Battery.—The whole of the armour plates are to be steel-faced, and to be manufactured by a firm holding contracts for similar plates to the order of the English Government.

The disposition and thicknesses of the protective materials to be in conformity with the details shown on drawings.

For a length of about 250 feet amidships there is to be a water-line belt of vertical armour, extending from 3 feet above the load-line to 4 feet below it. The thickness of the armour plates to be as follows:—

Upper strake, 4 feet broad, generally	10	inches thick.
" in the immediate wake of engines and boiler	11	"
Lower strake, 3 feet broad	7	"
Breastwork	10	"
Turrets above breastwork	10	"

The oblique interior armour at ends of vessel to be worked, as shown on drawings, at an angle of 15°, to be diminished in thickness from the side armour, so as to maintain a thickness, measured horizontally, of not less than 10 inches.

The oblique armour is to be composed of two layers of steel plates, the first to be ¾ inch thick, riveted up and caulked, to which is to be screwed the second layer, making together the specified thickness; the screws to be put in from the underside, so as not to wound the face of the armour.

The bolts must be screwed into the back of the armour plates, but not pass through the steel facing; nuts with india-rubber cup-washers will be required on the inner end of the bolts. All armour bolts to be of the best material, with shanks reduced in diameter where they pass through the backing.

Woodbacking.—To be 8 inches in thickness behind the 10-inch armour and 11 inches thick behind the 7-inch armour, to be secured to the skin plating by nut and screw bolts 1⅛ inch diameter, screwed up on the inside on washers and grummets.

The backing is not to be caulked, but is to be well fitted to the sides of the ship, and close jointed with a mixture of red and white lead or marine-glue pitch, as a setting between the joints. The holes for armour and backing bolts to be caulked between the two skins. The outer surface of the backing is to be completely coated with marine-glue pitch, before the armour is put on. Great care is to be taken to accurately bed the armour on the backing before putting on the waterproof glue.

Armoured Pilot Tower.—To be built on the fore end of the battery, as indicated on the drawings. Thickness of armour to be 10 inches, of backing 8 inches, and skin plating ¾ inch, with suitable vertical frames and bolts, and thin lining over the armour bolt heads.

Turrets.—The principal armament is to be four large breech-loading guns, as before stated, worked in two revolving turrets (two on each turret). The turrets are to be of sufficient height to fire over the upper deck of the vessel, and also to admit of the guns of each turret being fired simultaneously in a right forward and a right aft line. The guns of each turret are also to have an unobstructed fire through an angle of 180° on one side of the ship, and as much as practicable on the other side of the ship, and a depression of 5° through as large an angle of training as possible.

Each turret will have an internal diameter of about 17 feet, and external diameter of about 21 feet. The upper revolving part required to be built by the Contractors will be about 3 feet 6 inches to 4 feet in depth to the armour shelf. This upper revolving part of the turrets is to be plated with 10-inch steel-faced armour, with teak backing, frames, girders, inner steel lining, steel beams, and steel plating for the crown.

All the working parts of each revolving turret, and also the spaces required for loading, are to be protected by a fixed breastwork, plated with 10-inch steel-faced armour, with teak backing frames, &c. The breastwork to be of an approximately oval form, about 38 feet 6 inches long, and 25 feet broad external dimensions, and about 9 feet 6 inches to 10 feet in depth, or from about 2 feet above the upper deck down to the armour-plated main deck upon which the breastwork will be built. The upper part of the armour breastwork is to be plated all over with about 3-inch steel armour, leaving space only for the revolving turret to work.

All the lower part of the revolving turret, as shown in tint on the sectional drawing herewith, below the armour shelf, together with the guns, carriages, and all the machinery for loading and working the guns, will be supplied, under another contract, by Messrs. Sir W. G. Armstrong and Co.

The Contractors for the ship are to supply and fit the roller path for each turret with machined surface-beds of teak.

The following is Messrs. Sir W. G. Armstrong's specification of work to be done by the Contractors for the ship, in connexion with their mechanism:—

"The Contractors are to provide all skilled labour required for unloading all goods supplied by Messrs. Sir W. G. Armstrong and Co., and for fixing them in place ready for work, and attending during trials.

"The Contractors are also to construct the turret above the armour shelf of the turret and the whole of the battery, &c.

"They are also to unload and fix all mechanism outside the turret, as per following approximate list.

"Mechanism outside of turrets, supplied by Sir W. G. Armstrong and Co., consists, approximately, of the following, viz., per turret:—

"1 pumping engine.
"1 hydraulic turret-turning engine and gear.
"Tank, stand-pipes, and means of filling tank.
"Sighting-hoods, &c. on turrets.
"All platforms, gangways, &c.
"4 hydraulic rammers.
"4 " ammunition lifts and cases.
"1 turret centre-pivot, with communication for voice tubes, electric wires, pressure and exhaust water-pipes.
"1 lower roller path.
"1 lower turret clip-ring.
"1 hand pump.
"Pipes and pipe connexions.
"Powder cases and shot and shell.
"Pressure and exhaust pipes and connexions.
"Gear for moving ammunition.
"Sighting arrangements."

The Contractors are to arrange and provide in their drawings and specifications means of passing from one turret to the other, wholly below the armoured deck and within the armoured protection of the ship.

"Parts per turret to be supplied by shipbuilders are:—
"Voice communications and 'tell-tale,' and other signals in and about turrets and elsewhere, except at centre pivot of turret.
"All bolts required for fixing mechanism to the vessel.
"Machined surface-beds of teak, for roller path and clip ring below turret.
"Boiler power about 80-horse power.
"Steam and exhaust pipes to and from pumping engines.
"Water tank to contain about 3¼ tons of water and connexions to pumping engines."

Conning Tower.—To be provided in a suitable position.

To be protected by steel-faced armour 10 inches thick, efficiently supported, and to command a good all-round view, and to be of sufficient size for the gear which controls the steam steering engine, instruments for conveying orders to the engine-room, telegraphs, compass, &c., and to be capable of holding at least four persons.

Horizontal Armour on Decks.—On main deck as shown in drawings to be 2-inch steel in two thicknesses, the first to be ½ inch thick, riveted up and caulked, to which is to be screwed the second thickness, making up together the 2 inches specified. The screws to be put in from the underside, so as not to wound the face of the armour. Abaft the belt the lower deck is to be plated with 2 inches of steel, in two thicknesses for about 26 feet, abaft the oblique armour, and about 12 feet from the stern. Over the top of the breastworks, 3-inch steel plating is to be worked.

Armour bars of corresponding strength to be fitted to funnel hatch.

The engine hatch on main deck to be protected by hinged armour covers 2 inches thick, which can be closed in action.

All openings and hatchways, besides the engine hatch, in the protective plating on main and lower decks, to be furnished with suitable sliding armour covers, at least equal in thickness to the deck plating.

Watertight Platforms.—As shown on the drawings, of plates ½ inch.

Coal Bunkers.—As shown on the drawings to contain 800 tons of coal; made watertight and fitted with watertight doors, and screens wherever necessary.

EXTERNAL SHEATHING OF TEAK AND ZINC.

Keel.—Of English elm, 16 inches broad amidships by 9 inches thick, tapered forward and aft, secured by 1-inch bolts tapped to the keel plates, with nuts and grummets inside.

Wood Sheathing.—The whole of the surface of the bottom, extending 2 feet above the water line, is to be sheathed with wood worked in two thicknesses, the inner one to be 2½ inches thick on the outer plates of the bottom, and the outer 2 inches thick. Both thicknesses are to be worked fore and aft, breaking joint; the inner thickness is to be fastened with ¾-inch galvanized screw bolts, which are to be carefully screwed through the skin plating, and are also to have nuts on their points inside for double security. A thin iron washer is to be fitted under each nut with a hempen grummet between it and the plating. The bolts are be made thoroughly watertight.

The outer thickness is to be fastened to the inner thickness by gun-metal screw bolts, ⅝ inch diameter, care being taken that the holes are not bored through, and that the points of the bolts, when hove up, are always at least ½ inch clear of the skin plating.

The same size and length of gun-metal screw bolts to be used for securing the outside sheathing throughout, except the garboard strakes.

The bolts in the garboard strakes are to be increased in size proportional to the thickness.

The screw bolts, both in the inner and outer thickness of sheathing, are to be reduced in diameter at the screw thread by $\frac{1}{16}$ inch; care should be taken in the bolts for the inner thickness that the shoulders bear well upon the wood, compressing it about ⅛ inch. A grummet is to be used under the heads of the screw bolts. The slot or recess in the heads of the screw bolts, for heaving them up, is to be of an oblong form. Every bolt is to be hove carefully up by means of a rachet brace.

The bolt heads of the inner thickness are to be let in ⅝ inch within the outer surface of the plank, and the bolt heads in the outer thickness to be let in not more than ⅛ inch within the outside surface of the plank.

The heads of the bolts in both thicknesses of sheathing should be set in a mixture of white and red lead.

The heads of the bolts of the inner thickness are to be plugged with a mixture of white and red lead, and those of the outer thickness with an approved composition. The faying surface of both thicknesses of the sheathing, as also the steel plating against the inner thickness, to be well coated with a mixture of white and red lead. The butts of the outer thickness are to give good shift with the butts of the inner thickness, and a shift of butts is to be prepared and submitted for approval before the work is taken in hand. The whole to be worked in a most careful manner, stealers being avoided as much as possible in the sheathing; the planks to be not less than 24 feet in length, except at the fore and aft ends of the ship.

The caulking of both thickness of sheathing is to be very carefully done, so as to avoid strain on the fastenings.

The sheathings should be provided a little thicker than stated above to allow for fairing.

The inside and outside sheathing to be of teak of the very best quality. Garboards to be of English or Canada elm. The whole of the plank of every description is to be of the best and well-seasoned description, to ensure perfect water-tightness.

Before any sheathing is applied the bottom is to be thoroughly scraped and cleaned, and at least three coats of the best red lead or other approved composition is to be applied. The wood sheathing is to be coated on the inside and edges with a thick coat of red lead, or as may be directed. Before the yellow metal sheathing is applied the surface of the wood is to be covered with a thick coat of an approved composition.

Metal Sheathing.—To be generally 24 oz., extending 1-ft. above the load water line, secured to wood planking with metal nails.

The sheathing in way of anchors and on keel to be 32-oz. metal.

Bilge Keels.—To be of a V shape, not less than 2½ feet in width, and composed of brass plates of not less than 15.3 lbs. per foot, riveted at the outer edge to a §-inch plate placed between them and wide enough to take rows of rivets.

The space between the brass plates forming the bilge keels to be filled in with light wood or as may be directed.

The angle-bars connecting the bilge keels to the bottom to be 3 inches by 3 inches by not less than 8.27 lbs. per foot.

These angle-bars are to be tap riveted to the bottom plating, the rivets passing through it, and secured with a nut on the inside, hove up on a washer and grummet. Great care is to be taken in riveting the bilge keels, so that if they are torn off by the ship's grounding, or otherwise, the watertightness of the bottom will not be interfered with.

Deck Flats.—Upper deck.—The flat of upper deck in wake of cabins and closed-in portions to be of teak 2½ inches thick, secured to beams by nut and screw bolts, let in below the surface and dowelled over. The deck in way of capstan, riding bitts, deck pipes, masts, &c., to be of increased thickness. The deck in line of fire from the guns to be of steel as before described.

Flying deck of 2½-inch teak, caulked and tongued with iron tongues.

Main deck of Dantzic crown deals, 3 inches thick, secured to beams and deck plating by nut and screw bolts, or by bolts screwed into the steel plating.

Lower deck of Dantzic fir, 2½ inches thick, secured as main deck.

In the store-rooms to be gratings, made movable for painting the steel flats.

Waterways.—Flying deck to be a gutter waterway, 12 inches wide, covered all over with Portland cement.

Upper and main decks of teak, 9 inches wide by 3½ inches thick.

Coamings and Headledges.—For engine and boiler hatchways and ladderways to be of steel as before described; for skylights, companions, on flying deck to be of teak fitted with gratings to the hatchways of teak and American elm, and iron gratings over stokeholes.

Skylights on flying deck to be of teak, glazed with plate glass, and fitted with brass guards.

Brass stanchions and rails to be fitted round the after ladderways, and iron ones round the forward hatchways.

Mast Holes on Wedging Decks.—To be formed of angle-iron rings riveted to the deck plating.

Port Framing and Fittings.—The sides and sills of the battery ports to be lined with plates $\frac{7}{16}$ inch thick, and forgings fitted to receive the pivot blocks.

The port lids to be of steel $\frac{1}{2}$ inch, fitted with strong hinges, with metal pins, bars, and screws for closing.

Torpedo ports and ports for the 4¾-inch guns to be framed in iron, fitted with steel lids, with brass scuttles in centre, and chains and levers for opening and closing the ports.

All the ports to be made to close watertight with metal vee pieces on india-rubber.

Cabins.—The cabins for captain and officers to be made in accordance with the drawings—the doors of captain's cabin, officers' saloon, and the fore and aft framing abaft the turrets to be framed in teak with teak jalousies French-polished. The cabin framing to be pine, neatly painted, or grained oak and varnished where required.

The cabins to be fitted with bed berths, with drawers under, washstands, chests of drawers, shelves, and hat and cloak hooks; tables, seats, and sideboards for the mess-rooms. The fore part of vessel to be fitted for the crew, with mess tables and stools or lockers arranged to stow between the beams when not in use, and cupboards for stowing the mess kits.

Bag racks to complete the requisite number to be fitted below, if necessary.

Furniture and Lamps.—The necessary sofas, carpet for admiral's and captain's cabin, floor-cloth, looking-glasses, washstands, furniture, lamps for saloons and cabins, also for crew and for store-rooms and magazines, to be supplied and fitted complete.

Store Rooms.—All necessary store-rooms for captain, officers, engineers, and warrant officers, provision rooms, &c., to be built as shown on plans, and fitted with all requisite bins, racks, and shelves, cordage reels, and iron tanks.

Dispensary, Pantries, Water-Closets, Sail Room, Prison, and all other Offices.—To be built as per Plan, and fitted complete.

Capstan.—Of Brown and Harfield's patent wrought iron, arranged to be worked by steam, fitted with two pairs riding bitts and the necessary bow stoppers.

Also a wrought-iron warping capstan for quarter-deck.

Hawse-Pipes.—Of cast iron, two on each bow.

Deck Pipes for Chain Cables.—To be fitted where shown on plan, and fitted with compressors complete.

Ventilators.—Wrought-iron tubes with revolving cowls to be fitted to the engine and boiler rooms, cabins, store-rooms, and wherever required; also pipes and fan for ventilating the magazines and shell-rooms.

All necessary ventilation to be provided for spaces under the armour deck forward and aft.

Magazines and Shell Rooms.—The bulkheads to be of steel, $\frac{3}{16}$ inch thick, stiffened with angle-bars 3″ × 2½″ × $\frac{5}{16}$″ placed 30 inches apart on the inside, and to which are to be attached furrings for receiving the fastening of the magazine linings, which are to be of teak. For the sides and crown, the first lining to be 1½ inch thick, the second ¾ inch thick, arranged to break-joint.

The flat to be of teak, the first lining being 2 inches thick, and the

second 1 inch thick. Iron bolts or nails are to be used for the first and copper nails for the second lining in all cases.

The practice of the British Admiralty is to be followed with respect to the building, fitting, ventilating, and making watertight the magazines and shell-rooms.

Torpedo Armament.—The necessary arrangements to be made for torpedo magazines, store-rooms, and fittings for Whitehead torpedoes—the ports to be five in number, one for discharging directly astern, and two on each side for broadside.

Ceiling.—In holds the flats to be of Dantzic fir 2 inches think. The sides in store-rooms to be so arranged as to be easily accessible for cleaning and painting.

Ceiling between lower and main decks to be of Dantzic or red pine 1 inch thick.

Ceiling between main and upper decks, the lower strake to be of teak, 1½ inches thick, fitted on waterway and caulked. The sides to be lined with 1¼ inch teak, matched and beaded.

Care is to be taken that only such parts of the vessel are lined as really require it, in order that the weight of hull and amount of combustible material in the ship may not be unnecessarily increased.

Bulwarks.—The sides of vessel above the flying deck to be fitted with iron stanchions and rails all around, and suitable boxes for stowing hammocks to be provided where convenient.

Drainage and pumping arrangements.—Between the inner and outer bottoms and between the vertical keel and the 1st longitudinal on one side of the ship, a watertight iron drain pipe, 12 inches in diameter, is to extend thoughout the double bottom, joined together with common flanges, and not to have expansion joints.

Immediately before each bulkhead, and wherever necessary, a drain or cistern is to be formed between the inner bottom and the main drain pipe, its lower part opening into the drain pipe, so that water will pass immediately from all parts of the inner bottom through the drains, and into the main drain pipe.

The water will be pumped from the drain pipe by the steam pump, which is to connect with the drain pipe at its lowest point.

The drain pipe is to be very firmly secured to the watertight frames, and to every bracket floor plate, to prevent the possibility of its being moved by the pressure of water acting on it, should any of the compartments become filled.

Provision is to be made for dealing with the compartment on each side the middle line watertight bulkhead by the single main drain pipe.

Each opening from the drains into the common drain pipe is to be protected by a self-acting valve, which will close if any compartment above the double bottom be filled with water, and prevent the water passing into the lower compartment by way of the drain-pipe.

As an additional precaution in the event of the failure of the self-acting valve, another valve is to be fitted to each drain, worked by a lever from the deck, and so fitted as to indicate when the valve is open or shut; the rod to work as close to the bulkhead as possible.

Suction pipes are also to be led from two of the Downton's pumps, fitted as may be directed, to be used for pumping out the drain pipe when the steam is not up.

Suction pipes leading into the drain pipe to have their extremities enlarged, and a strainer fitted over them opening into the drain pipe, to prevent choking.

A detailed sketch of pumping and draining arrangements, showing the kind of material proposed to be used, is to be submitted to the Overseer for his approval before the work is taken in hand.

At some convenient place at the after end of each watertight compartment of the double bottom, a short stand pipe is to be led from the inner bottom to within an inch or two of the outer bottom.

A suction pipe from the steam pump, and from two of the Downton's pumps, will be attached to the stand pipes, or a longitudinal pipe in connexion with them, so that any one of these pumps may be made available for pumping out either of the compartments.

The bottoms of the stand pipes are to be enlarged, and will not require roses.

Pumps, Sluice Valves, &c.—The pumps for pumping bilge, washing decks, and fire purposes to be as follows, viz.:—

One 5½-inch pump for fresh water. Two 9-inch pumps for bilge and fire service. Three 7-inch pumps for bilge and fire service.	To be Downton or other pumps of equal power.

Each of these pumps to be fitted with bilge suctions, leading into each of the compartments adjacent to it, with a suction leading to the sea through a Kingston valve, and a short suction to be connected by a fixed pipe, as may be required, with the standpipes in double bottom already described.

The 9-inch pumps, in addition to these suctions, are to be connected with the main drain pipe by separate suctions as already mentioned. At each of the bilge suctions in the double bottom there is to be a pocket or drain fitted to receive the end of the suction pipe, which pocket is not to be connected with the main drain pipe; all the pumps to be fitted complete for extinguishing fire (with wash-deck arrangements where required), with all necessary Kingston and other valves, cocks, stand pipes, unions, and all other fittings complete, as may be required.

The pumps and Kingston valves to be of Admiralty pattern.

Sluice valves are to be fitted at the watertight bulkheads, one at each end of the main drain pipe.

Sluice and other valves necessary for draining the several compartments, watertight flats, engine and shaft bearers, shaft passage, &c., to be fitted as required.

Pumps are to be fitted so as to discharge bilge water through the scuppers.

All the pumps, copper and other pipes, pipes for salt and fresh water and general purposes, mixed metal valves, cocks, and other fittings; lift pumps for filling baths, cisterns to water-closets, deck tank, galley, seamen's round houses, &c., to be supplied and fitted by the Contractor, of the materials, sizes, and patterns now used in H. M. Service; the lift pumps tinned are to be fitted where required, and copper and other pipes are to be cased where required. The gearing for working the pumps to be on the most approved plan, so as to work them independently on the two decks, if required, and to be marked and stowed as required. The roses of all bilge, suction, and injection pipes are to be made of zinc, zinced or enamelled iron, or other approved material, and not of copper. If the above pipes are of copper, the lower portions, which are liable to be immersed in bilge water, are to be formed of zinc, zinced or enamelled iron, or other approved material, so as to prevent galvanic action between the copper and iron.

All necessary eye-bolts, valves in deck, &c. are to be fitted for draw-

ing the boxes of the pumps; also all spare gear, lockers for stowing spare gear, cranks for stowing hose, to be fitted where required.

The hoses to be supplied for each pump in sufficient length to command either end of the vessel.

Great care is to be taken in the arrangement of the pipes that no copper or metal is introduced in any part of the ship so low as to come into contact with the bilge water that may be in the ship.

The Contractor is to furnish a complete detailed drawing, as fitted, of all the pumps, leads of pipes, drainage arrangements, positions of suctions, sluice valves, Kingston valves, and other holes in the bottom, including the holes cut by the engineers. The dimensions of all pipes, valves, &c. to be figured, and the positions of the holes in the bottom are to be inserted in figured distances on the round of the bottom in relation to the topside rail. Brass plates are to be fitted on the topsides indicating the openings in the ship's bottom, and the distances before mentioned.

Watertight Doors, Sluice Valves, Manholes, &c.—Watertight doors of an approved pattern are to be fitted in the bulkheads where shown on the drawings, or wherever necessary. The watertight doors in hold are to open and shut from the main deck, or so fitted that they can be closed rapidly from below. A sounding tube is to be fitted to each watertight compartment, or watertight space; also a sluice-valve or cock, wherever necessary, fitted with levers or rods for opening and shutting them, such rods to pass through stuffing boxes, where necessary. The sluice valves are to be worked from the main deck; the rods, where connected together, are to have brass bolts, and all levers to be brass bushed.

Sea cocks or valves are to be fitted through the side, where necessary, with copper pipes or cocks leading therefrom, for the purpose of flooding magazine. The whole of the cocks and valves are to be worked from the main deck, and the pipes are to be cased with wood or iron plating, wherever necessary. Socket levers are to be fitted for opening and shutting the valves, cocks, and watertight doors, and are to be stowed near the work, the plates on the deck to be marked with large sunken letters in a legible manner. Means are to be taken for indicating on the deck whether watertight doors in hold, sluice valves, &c. are open or shut. Manholes, 15″ × 23″, are be cut where required. Where it may be desirable to retain steel for strength, they may be made 14″ × 20″.

Watertight Compartments to be tested.—All watertight bulkheads are to be tested, and all defects discovered to be made good, made watertight, and re-tested till found perfect.

Catheads.—Of wrought iron, fitted with blocks and falls, cleats and stoppers, complete.

Bollards and Warping Chocks.—Of cast iron, to be fitted on upper deck, where required.

Stopper Bolts.—To be fitted in deck, where necessary.

Clench of Cables.—Provision is to be made for receiving the clench of the cables by suitable forgings.

Hawser Rollers, Cordage Reels, and Rollers to Working Hatchways.—To be fitted where required.

Fittings.—All necessary fittings for working or stowing the anchors, cranks for capstan bars, hooks for handspikes, eye-bolts for cables, &c., to be fitted complete. Pin racks, eye-bolts, cleats, and kevils, with all necessary leads, &c. for working the rigging, to be fitted complete.

Armament and Ammunition Fittings.—The whole of the armament, racers, gun sockets, and pivots, also turret engines, turntables, hy-

draulic and other gear for working the guns, are to be supplied by the Brazilian Government, but fitted by the Contractor, who is also to furnish and fix all necessary hand-up scuttles for powder, shot and shell, eye-bolts, ring and eye bolts to ports; port lids, or bucklers, shot racks of wood or iron, lamps to magazine, shell-room, and spirit room; cranks for rammers and sponges, arm racks, armourer's bench, and all requisite fittings complete, racks for boarding pikes arm stands, armourer's bench.

Steering Apparatus and Rudder.—To be fitted with a wrought-iron tiller and steam steering apparatus, also with steering wheels for working by hand, tell-tale in front of wheels, relieving tackles with eye-bolts, &c., complete.

The rudder head and tiller and steering arrangements are to be wholly below the lower edge of the armour protection.

The frame and head of the rudder to be in one casting of gun-metal; the frame is to be filled in with wood, and plates (of the same composition as the frame) of 10 lbs. to the square foot are to be securely riveted to the frame; these plates are also to be screwed to the wood.

The rudder to be fitted so as to unship when the ship is docked upon the ordinary height of blocks. To have tiller blocks, chains, rudder pendants, ring plates, stop cleats, stuffing boxes, holes and eye-bolts for guys, tackles, &c., for hanging rudder, and screw-bolts in the rudder head, and suitable means for locking the rudder, with such other fittings as are required to complete the steering apparatus.

A suitable arrangement is to be made so that the upper part of the rudder may work with a close joint round the casting and counter at the head of the stern post, in order to effectually prevent ropes, sea weed, or any other substance interfering in any way with its efficient working.

Compasses, &c.—Compasses, binnacles, and standard compass to be supplied and fixed complete, with all supports, stands, steps, rooms, or lockers for spare compasses, &c., including all necessary gear, as is usual in the British Navy.

The following compasses are to be supplied and properly adjusted, the Contractors bearing the cost of swinging the ship, &c.:—1 standard, 1 azimuth, 3 steering, 6 steering cards, 1 steering liquid, 6 boat, including 2 liquid, 1 hanging or tell-tale, 1 box with 6 cards and 6 spare glasses, with other usual spare gear.

Tanks for Fresh Water.—Capable of containing 7,000 gallons of water to be provided and fitted in hold.

Water-closets for Officers and Seamen.—Are to be fitted, as shown on plan, with all necessary cisterns, &c. complete.

Baths.—To be fitted where shown on plan, with all necessary pipes, pumps, copper, steam-pipes for heating, &c.; complete.

Boats.—To be supplied with one second-class torpedo boat as used in the British Navy, one steam pinnace, two cutters, one gig, one life gig, and one jolly boat, with wrought-iron davits, blocks, falls, and guys complete.

Derrick to be fitted to main mast with suitable gear for lifting the larger boats.

Awnings.—A complete set of awnings to be fitted all fore and aft, with iron stanchions and wire ridge ropes.

Tarpaulins or Covers.—To be provided for each hatchway, sky-light, binnacle, and steering-wheel.

Accommodation Ladders.—With stools, rails, and man-ropes, to be fitted complete; also rope ladder for crew.

Masts and Rigging.—The vessel to be square rigged as per plan. The masts to be of steel, standing rigging of wire rope, running rigging of best hemp, with all necessary blocks, complete; to be fitted with lightning conductors on Sir Snow Harris' principle.

Sails.—A complete suit, in accordance with the plan, to be supplied, also spare sails.

Anchors.—Two sheet anchors, 60 cwt. Martin's pattern.
Two bower " 70 " Admiralty pattern, exclusive of stocks.
One stream, 20 cwt.; one kedge, 15 cwt.; and one 8 cwt.

Cables.—450 fathoms $2\frac{1}{8}$-inch chain cable.
100 " $1\frac{1}{4}$ " "
One mooring swivel.
Anchors and cables to be proved to Admiralty tests.

Hawsers.—100 fathoms 15-inch hemp.
100 " 12 " "
100 " 8 " "
100 " $6\frac{1}{2}$ " "
100 " $5\frac{1}{2}$ " "
100 " $4\frac{1}{2}$ " "
100 " $3\frac{1}{2}$ " "

Galleys.—Of suitable dimensions to cook for captain, officers, and crew of 250 men. A separate galley for the officers is to be provided, and one for the crew.

Painting.—All ironwork to have three coats of red lead or black. Woodwork to have four coats. Officers' cabin to be grained oak, and varnished where required.

Cement.—Inside the vessel, as high up as the bilges, to be coated with Portland cement, and wherever necessary to drain the water to the limber holes.

Signal Lamps.—2 bow.
1 mast-head.
1 riding lantern.

Sundries.—4 nunn buoys.
2 deep-sea leads, lines, and reels.
4 hand leads and lines.
2 log lines and reels.
4 log glasses.
1 patent log.
12 leather buckets.
12 wood ditto.
12 paint scrubbers.
12 deck ditto.
12 brooms.
12 flags.
4 cork fenders.

It is to be distinctly understood that the Contractor is to supply, fit, and complete in every respect all other detailed fittings, including the following:

Mould for Rudder.—

Spare Blades to Propeller.—To be stowed and secured.

Distilling Condensers, &c.—The distilling condensers, filters, Kingston's valves, and sea cocks through the bottom to be supplied and fitted by the Contractor. All the pipes connecting the receiving tanks with the condensers, and cocks and air-pipes from the condensers, are to be supplied by the Contractors, and fitted in the manner usual in Her Majesty's Service. The pipes connecting the distilling condensers with

the boilers are to be fitted and supplied by the Contractor; the pipes to be stayed and cased by the shipbuilder when required. Brass plates on the vessel's sides, bulkheads, and deck, indicating thereon the position of Kingston's sea pipes, &c.

Iron and other Tanks.—Iron tanks are to be fitted in officers' mess berths, and dispensary, and also a filter tank for daily supply on the lower deck. Tank with brass tap in landing-room to magazine, and provision tanks in issue-room.

Handholds.—To be fitted wherever necessary to the bulkheads in hold.

Ladders to Hatchways.—Are to be of wood or galvanized iron as may be required, and to be fitted as shown on the plans.

Gratings, or Cap Scuttles.—Gratings or cap scuttles, or both as may be required, are to be fitted to the hatchways, and to all the ladderways and scuttles. The gratings are to be either of wood or iron. Over the engine and stoke-hole hatches the bars of the gratings are to be formed of round iron. Hatch-bars, with locks, to be provided where required.

Guard Rails and Stanchions to Hatchways, &c.—To be fitted where required.

Towing and Lashing Bollards.—To be fitted as shown on the drawings, and as may be required.

Transporting Chocks.—To be fitted to the upper deck ports where required.

Mouldings.—Mouldings on beams.

Arris-Pieces on Beams.—To be fitted in hatchways and wherever else required.

Scuppers on Upper Deck.—Scuppers are to be fitted to the upper and flying decks in number and position as shall be required. To be fitted with mixed yellow metal gratings, covers, flaps, &c., of approved composition. The scuppers are to be formed of wrought iron or lead, with mixed yellow metal flanges of approved composition, to be completed as is usual in Her Majesty's Service for vessels of this class.

Voice Pipes and Telegraphs.—The voice pipes are to be made of copper, with mouth-pieces, whistles, stop-cocks, and wire gauze diaphragms where necessary, and to be fitted wherever required. Care is to be taken to break the continuity of the copper pipes, in order that they shall not be conductors of lightning to the magazines.

Telegraphs from conning tower and wherever necessary to be fitted, also rudder indicator in conning tower and on bridge.

Engine room, Artificers' Mess Place.—To be fitted complete with tables, lockers, &c. as may be required.

Clerks' Office.—To be fitted complete with pigeon holes, drawers, desks, cupboards, stools, &c.

Stewards' Pantries.—All stewards' pantries are to be fitted with all the usual lockers, drawers, bins, glass and plate racks, hooks, sideboards, shelves, desks, &c.

Issue Room.—To be fitted with bins, lockers, shelves, &c.

Chronometer.—Closet and compass card boxes.

Cabin Furniture.—The cabins are to be fitted complete with all bed-places, cots, drawers, bookshelves, hat and coat pegs, tables, wash and other stands, shelves, sideboards, lockers, and all other fittings (exclusive of bedding and upholstery) complete in every respect, agreeably to the practice in Her Majesty's Service for vessels of this class.

Ash Shoots.—To be fitted where required.

Coaling Scuttles.—Coaling scuttles, 18 inches in diameter in the clear, are to be fitted with suitable castings and covers in number and position, as shown upon the drawings, or as required. Gratings are to be

fitted in addition to solid covers where required. The whole to be as usual in Her Majesty's Service, and stowed where required.

Flat of Gangways.—To be sheathed with copper or brass corrugated plate.

Carved Work.—The head and stern of vessel to be ornamented with suitable carved work.

Fittings.—Signal lockers, lockers for wash-deck gear, life buoys and guards, eye-bolts to funnel stays, bow lights, man-rope stanchions, bolts in upper and lower deck beams, eye and other bolts, wherever required, for the purpose of removing casks and packages, cranks between deck beams, hawser rollers, &c., cordage reels, rollers for working hatchways, and all similar fittings, lumber irons under the lower deck and in hold, cooks' cupboard, cooks' table with cranks, &c., coal box for galley of plate iron, fowl coops, seamen's library, boxes for marines' helmets, racks for seamen's hats and ditty boxes, to be fitted complete as usual in Her Majesty's service.

Meat Safes and Screens.—Meat safes and screens round the galley, and in other places, are to be fitted as is usual in her Majesty's Service for vessels of this class. Also screens of iron or wood, lined with tin round the galley; beef screens and bars, and hooks for hanging up meat, are to be fitted if required.

Hammock Hooks.—Hammock hooks for berthing the crew are to be fitted to the upper and flying deck beams.

Stoves for Cabins.—The stoves are to fitted complete with the necessary copper and other funnels, and all fittings by the Contractors, including brass rims and covers for passing the funnels through the upper deck, &c.

Watch Bell.—A watch bell of an approved kind and size is to be provided and fitted.

Cabin Bells or Gongs.—To be supplied and fitted as required.

Locks, Keys, &c.—All locks, keys, and other fastenings, exclusive of spare, are to be fitted complete of approved patterns. All keys are to be furnished with brass tallies marked in a legible manner.

Brass Label Plates.—To be fitted, where required, for showing the positions of all cocks and valves in the bottom of the vessel, also cabins, store-rooms, &c.

Cleaning, Galvanizing, Painting, and otherwise Coating Steel and Iron Work.—All steel and iron work is to be carefully scraped and cleaned before being painted, and each portion of it as it is turned out of hand is to have a coat of thin red lead or other substance as may be required, as soon as it is sufficiently completed to receive it, in order to prevent, as far as possible, the steel and iron work from becoming in any degree oxidized during the building of the vessel.

All iron awning stanchions, guard stanchions, and rails, gratings, bolts, coal-scuttle frames and lids, rubbing plates, armanent fitting, and all fittings exposed to the weather or to damp, are to be carefully zinced.

Caulking.—The whole of the caulking in the vessel is to be performed in the most satisfactory manner, and as is usual in H. M. Service; observing that if it should be found necessary, before the vessel is delivered up by the Contractor, to re-caulk the decks and reconcile the edges, the same shall be done by and at the expense of the Contractor.

Inspection.—The Contract is to be executed in every respect to the satisfaction of Admiral Azevedo, who will have the right, as he may see fit, to appoint officers to inspect the manufacturing of the steel and iron, and also to test it in the usual way, and to inspect the workmanship during the progress of building and fitting the vessel, for the purpose of

ascertaining and ensuring that the Contract is being properly carried out.

The Contractor is to give every facility for testing all materials worked into the hull; a testing machine is to be erected on the Contractor's premises; the testing will be supervised by the Overseer; the whole of the expense to be borne by the Contractor.

Completion.—This Contract is intended to include the entire completion of the vessel for sea, as is usual in Her Majesty's Service, with the exceptions herein set forth.

It is, therefore, to be expressly understood that all minor fittings which may not be shown on the drawings or mentioned in this Specification, but which may be requisite for the proper completion of the vessel for sea, as is usual in vessels built for the English Government, are to be provided by the Contractor without additional charge.

It is also to be expressly understood that if any omissions exist in this Specification or drawings, such omissions are to be supplied; and the Contractor is bound to comply with the parts thus specified without extra charge, in the same manner as if they had formed part of the original Specification or the drawings. Also that, as it may be desirable to omit to perform some of the works herein described, or to perform them in a less costly manner, any expense of material or labour thus saved is to be placed to the credit of the Government as a set-off against any extra works which they may require the Contractor to perform.

The vessel to be constructed generally in accordance with the annexed drawings numbered ——.

The vessel to be launched by the Contractor at his own risk and cost, and sent at his cost to such place or places to receive her machinery, &c., and placed, while receiving her machinery, &c., and being completed, in a berth where she will not at any time touch the ground, and with the distinct understanding that until the vessel is completed according to the Contract and delivered, the Contractor is to pay all dock and harbour dues and charges, notwithstanding that works not included in the Contract may be in progress at the same time as the works and fittings which are included in the Contract.

Patent Rights.—The Contractor is to be responsible for the payment of the Patentees, should there be any infringement of patent rights in the construction of the vessel.

Machinery required in Building.—All machinery, &c., of whatever kind, required in building the vessel, is to be supplied by the Contractor.

Exceptions.—The vessel to be entirely completed and ready for service in accordance with this Specification and the drawings with the following exceptions:—Guns and ammunition, plate, linen, glass, earthenware, and cutlery, sea and steward's consumable stores, and nautical instruments beyond those named.

RETURN

RESPECTING THE

SHIPS BUILT AND BUILDING FOR THE BRITISH NAVY, 1880 TO 1885.

[Return to an order of the Honorable The House of Commons, dated December 2 1884.—Admiralty April 14, 1885.]

RETURN OF SHIPS BUILT AND BUILDING

Statement of the armored and unarmored ships laid down to build in Her Majesty's dock-ticulars, together with the armored and unarmored tonnage built in Her Majesty's dock-

[NOTE.—The particulars in this return

Names.	Tons displacement.	Tons weight of hull.	Indicated horse-power.
Ships built at Sheerness, Devonport, Portsmouth, and Chatham are built in Government dock-yards; the others are built in private yards.			
1880-'81.			
ARMORED.—*Barbette ships.*			
COLLINGWOOD	9,150	6,190	9,500
Dates: Commenced building July 12 1880; launched Nov. 22, 1882; estimated to be completed March, 1886. *Where and of what built*: At Pembroke; of steel. *Maker of engine*: Humphrys. *Thickness of armor plating*: On sides, 18"; bulkheads, 10"; barbettes, 11½" and 10"; conning tower, 12" and 9"; armor tubes, 12" and 10"; screen bulkheads, 6"; decks, 2½"; skin plating, 1". *Backing*; Teak, 17" to 10". *Armament*: Barbettes, four 12" 43 ton B. L. R. Upper deck, six 6" 89 cwt. B. L. R.			
UNARMORED.—*Partially protected steam cruisers.*			
ARETHUSA	3,750	1,675	5,000
Dates: Commenced building June 14, 1880; launched Dec. 23, 1882; estimated to be completed in 1883-'86 *Where and of what built*: At Napier's, Glasgow; of steel. *Maker of engine*: Napier. *Armament*: Upper deck, ten 6" 89 cwt. B.L.R.			
LEANDER	3,750	1,675	5,000
Dates: Commenced building June 14, 1880; launched Oct. 28, 1882; estimated to be completed Mar. 31, 1885. *Where and of what built*: At Napier's, Glasgow; of steel. *Maker of engine*: Napier. *Armament*: Upper deck, ten 6" 89 cwt. B. L. R.			
PHAETON	3,750	1,675	5,000
Dates: Commenced building June 14, 1880; launched Feb. 27, 1883; estimated to be completed in 1885-'86. *Where and of what built*: At Napier's, Glasgow; of steel. *Maker of engine*: Napier. *Armament*: Upper deck, ten 6" 89 cwt. B.L.R.			
UNARMORED.—*Partially protected sloops.*			
SATELLITE[1]	1,420	780	1,500
Dates: Commenced building Oct. 4, 1880; launched Aug. 13, 1881; completed Nov., 1882. *Where and of what built*: At Sheerness; composite. *Maker of engine*: Humphrys. *Armament*: Upper deck, eight 6" 81 cwt. B. L. R.			
HYACINTH[1]	1,420	780	1,470
Dates: Commenced building Aug. 30, 1880; launched Dec. 20, 1881; completed July, 1883. *Where and of what built*: At Devonport; composite *Maker of engine*: Humphrys. *Armament*: Upper deck, eight 6" 81 cwt. B. L. R.			
HEROINE[1]	1,420	780	1,470
Dates: Commenced building Aug. 30, 1880; launched Dec. 3, 1881; completed Oct., 1882. *Where and of what built*: At Devonport; composite. *Maker of engine*: Humphrys. *Armament*: Upper deck, eight 6" 81 cwt. B. L. R			
UNARMORED.—*Gunboats.*			
STARLING	465	260	440
Dates: Commenced building Aug. 19, 1880; launched April 19, 1882; completed June, 1882. *Where and of what built*: At Samuda's, Poplar; composite. *Maker of engine*: Rennie. *Armament*: Upper deck, two 64-pdr. 64 cwt. M. L. R; two 20-pdr. B. L. R.			
STORK	465	260	440
Dates: Commenced building Aug. 19, 1880; launched May 18, 1882; completed Dec., 1882. *Where and of what built*: At Samuda's, Poplar; composite. *Maker of engine*: Rennie. *Armament*: Upper deck, two 64-pdr. 64 cwt. M. L. R.; two 20-pdr. B. L. R.			
RAVEN	465	260	440
Dates: Commenced building Aug. 19, 1880; launched May 18, 1882; completed Dec., 1882. *Where and of what built*: At Samuda's, Poplar; composite. *Maker of engine*: Rennie. *Armament*: Upper deck, two 64-pdr. 64 cwt. M. L. R.; two 20-pdr. B. L. R.			

[1] Reclassified as a corvette in July, 1883. [2] Estimated.

[3] Speed deduced from trials of sister-ships.

FOR THE BRITISH NAVY, 1880 TO 1885.

yards and by contract, since April, 1880, showing the cost, armament, speed, and other par-
yards and by contract, and the total naval expenditure from 1865–'66 to 1883–'84, inclusive.

have been corrected to March 18, 1885.)

Length between perpendiculars.	Breadth, extreme.	Draught of water (sea-going). Forward.	Draught of water (sea-going). Aft.	Speed at normal draught of water.	Capacity for coals.	Complement.	Estimated first cost of vessels building in Her Majesty's dock-yards and in private yards. Hull (inclusive of fittings).	Engines (inclusive of fittings).	Total.	Total cost of hull and engines of vessels building in Her Majesty's dock-yards and in private yards, when completed. Hull (inclusive of fittings).	Engines (inclusive of fittings).	Total.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Knots.*	*Tons.*		£	£	£	£	£	£
325	68	[2]25½	[2]26½	[2]16.0	1,200	423	466,150	[4]87,500	553,650	Incomplete.		
300	46	[2]17½	[2] 0½	17.0	1,000	257	86,763	58,435	[4]145,198	Incomplete.		
300	46	[2]17½	[2]20½	17.0	1,000	257	87,843	60,610	[4]148,453	Incomplete.		
300	46	[2]17½	[2]20½	17.0	1,000	257	86,763	58,435	[4]145,198	Incomplete.		
200	38	[2]12¾	[2]15¾	[2]13.0	400	161	48,623	[4]13,050	61,673	47,313	15,407	62,720
200	38	[2]12¾	[2]15¾	[2]12.0	400	159	52,100	[4]13,050	65,150	53,427	14,516	67,943
200	38	[2]12¾	[2]15¾	13.0	400	159	52,100	[4]13,050	65,150	52,451	14,438	66,889
125	23½	8½	10½	9.75	40	60	12,350 1,868	5,900	[4]18,250 [5]1,868	14,840	6,269	21,109
125	23½	8½	10½	9.75	40	60	12,350 1,360	5,900	[4]18,250 [5]1,360	14,906	6,238	21,144
125	23½	8½	10½	9.75	40	60	12,350 1,360	5,900	[4]18,250 [5]1,360	14,799	6,234	21,033

[2] Constructor's estimated speed, with forced draught.
[4] Contract price.
[5] Estimated cost of completing for sea in dock-yard.

Statement of the armored and unarmored ships laid down to build in Her

Names.	Tons displacement.	Tons weight of hull.	Indicated horse-power.
UNARMORED.—*Special service vessels.*			
ALECTO (paddle steamer) ..... *Dates*: Commenced building Jan. 16, 1881; launched April 18, 1882; completed July, 1882. *Where and of what built*: At Westwood & Co.'s, Cubitt Town; composite. *Maker of engine*: Rennie. *Armament*: Upper deck, four 4" 13 cwt. B. L. R.	620	350	490
TRITON (paddle-surveying vessel) ..... *Dates*: Commenced building Aug. 19, 1880; launched Mar. 4, 1882; completed Mar., 1882. *Where and of what built*: At Samuda's, Poplar; composite. *Maker of engine*: Maudslay. *Armament*: Upper deck, one 7-pdr. 200 lbs. M. L. R.	410	240	370
SUPPLY (screw tank vessel) ..... *Dates*: Commenced building Dec. 16, 1880; launched Aug. 11, 1881; completed Dec., 1881. *Where and of what built*: At Laird's, Birkenhead; of iron. *Maker of engine*: Laird.	250	108	120
BEE (screw lighter) ..... Purchased July, 1880. *Where and of what built*: At Osbourne, Graham & Co.'s, Sunderland; of iron. *Maker of engine*: Pattison & Co.	320	110	120
1881-'82.			
ARMORED.—*Barbette ships.*			
RODNEY ..... *Dates*: Commenced building Feb. 6, 1882; launched Oct. 8, 1884; estimated to be completed Dec., 1886. *Where and of what built*: At Chatham; of steel. *Maker of engine*: Humphrys. *Thickness of armor plating*: On sides, 18"; bulkheads, 16"; barbettes, 11¼" and 10"; conning tower, 12" and 9"; armor tubes, 12"; screen bulkheads, 6"; decks, 3" and 2½"; skin plating, 1". *Backing*: Teak, 17" to 10". *Armament*: Barbettes, four 13.5" 64 ton B. L. R. Upper deck, six 6" 80 cwt. B. L. R.	9,700	6,330	9,500
IMPERIEUSE ..... *Dates*: Commenced building Aug. 10, 1881; launched Dec. 18, 1883; estimated to be completed Jan., 1886. *Where and of what built*: At Portsmouth; of steel. *Maker of engine*: Maudslay. *Thickness of armor plating*: On sides, 10"; bulkheads, 9"; barbettes, 8"; armor tubes, 3"; conning tower, 10"; decks, 4" and 2"; skin plating, 1". *Backing*: Teak, 10". *Armament*: Barbettes, four 9.2" 18 ton B. L. R. Upper deck, six 6" 80 cwt. B. L. R.	7,390	5,000	8,000
WARSPITE ..... *Dates*: Commenced building Oct. 25, 1881; launched Jan. 20, 1884; estimated to be completed in 1885-'86. *Where and of what built*: At Chatham; of steel. *Maker of engine*: Penn. *Thickness of armor plating*: On sides, 10"; bulkheads, 9"; barbettes, 8"; armor tubes, 3"; conning tower, 10"; decks, 4" and 2"; skin plating, 1". *Backing*: Teak, 10". *Armament*: Barbettes, four 9.2" 18 ton B. L. R. Upper deck, six 6" 80 cwt. B. L. R.	7,390	5,000	8,000
UNARMORED.—*Partially protected steam cruiser.*			
AMPHION ..... *Dates*: Commenced building April 25, 1881; launched Oct. 13, 1883; estimated to be completed Dec. 31, 1885. *Where and of what built*: At Pembroke; of steel. *Maker of engine*: Maudslay. *Armament*: Upper deck, ten 6" 80 cwt. B. L. R.	3,750	1,675	5,000
UNARMORED.—*Partially protected corvettes.*			
CALLIOPE ..... *Dates*: Commenced building Oct. 1, 1881; launched June 24, 1884; estimated to be completed Dec. 31, 1885. *Where and of what built*: At Portsmouth; of steel and iron. *Maker of engine*: Rennie. *Armament*: Upper deck, four 6" 80 cwt. B. L. R.; twelve 5" 36 cwt. B. L. R.	2,770	1,470	3,000
CALYPSO ..... *Dates*: Commenced building Sept. 1, 1881; launched June 7, 1883; estimated to be completed Mar. 31, 1885. *Where and of what built*: At Chatham; of steel and iron. *Maker of engine*: Rennie. *Armament*: Upper deck, four 6" 80 cwt. B. L. R.; twelve 5" 36 cwt. B. L. R.	2,770	1,470	3,000

[1] Constructor's estimated speed, with natural draught.
[4] Estimated. [5] Purchase money.

Majesty's dock-yards and by contract since April, 1880, &c. —Continued.

Length between perpendiculars.	Breadth, extreme.	Draught of water (sea-going). Forward.	Draught of water (sea-going). Aft.	Speed at normal draught of water.	Capacity for coals.	Complement.	Estimated first cost of vessels building in Her Majesty's dock-yards and in private yards. Hull (inclusive of fittings).	Engines (inclusive of fittings).	Total.	Total cost of hull and engines of vessels building in Her Majesty's dock-yards and in private yards when completed. Hull (inclusive of fittings).	Engines (inclusive of fittings).	Total.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Knots.*	*Tons.*		£	£	£	£	£	£
160	26½	8 5/12	8 5/12	[1]10.0	75	68	18,765 1,700	8,950	27,715 [2]1,700	22,223	9,393	31,616
145	23 1/24	7	7½	9.9	55	40	12,300 1,150	7,500	[3]19,800 [2]1,150	13,853	8,236	22,089
104	19½	[4]7	[4]7	7.5	18	.....	5,500	2,994	[3]8,494	5,927	3,127	9,054
117	19	6½	8	.....	25	.....	4,200		[5]4,200	4,200		[5]4,200
325	68	[4]26½	[4]27½	[6]16.0	1,200	445	455,680	[3]102,000	557,680	Incomplete.		
315	62	[4]24 [8]	[4]25 5/12	[6]16.0	1,200	491	380,000	[3]104,500	484,500	Incomplete.		
315	62	[4]24 5/12	[4]25 5/12	[6]16.0	1,200	491	350,000	[3]107,600	457,600	Incomplete.		
300	46	[4]17½	[4]20½	[1]17.0	1,000	257	108,780	[3]65,500	174,280	Incomplete.		
285	44½	[4]17 5/12	[4]19 1/12	[1]13.75	550	281	90,620	[3]38,000	128,620	Incomplete.		
285	44½	[4]17 5/12	[4]19 1/12	[1]13.75	550	281	98,100	[3]38,000	136,100	Incomplete.		

[1] Estimated cost of completing for sea in dock-yard. [3] Contract price.
[4] Constructor's estimated speed, with forced draught.

Statement of the armored and unarmored ships laid down to build in Her

Names.	Tons displacement.	Tons weight of hull.	Indicated horse-power.
UNARMORED.—*Partially protected sloops.*			
CAROLINE[1]	1,420	780	1,500
Dates: Commenced building Oct. 24, 1881; launched Nov. 25, 1882; complete except planing decks. *Where and of what built*: At Sheerness; composite. *Maker of engine*: Maudslay. *Armament*: Upper deck, fourteen 5″ 36 cwt. B. L. R.			
RAPID[1]	1,420	780	1,500
Dates: Commenced building April 21, 1881; launched Mar. 21, 1883; completed July, 1884. *Where and of what built*: At Devonport; composite. *Maker of engine*: Maudslay. *Armament*: Upper deck, two 6″ 81 cwt. B. L. R; ten 5″ 36 cwt. B. L. R.			
ROYALIST[1]	1,420	780	1,500
Dates: Commenced building April 27, 1881; launched Mar. 7, 1883; completed Nov., 1884. *Where and of what built*: At Devonport; composite. *Maker of engine*: Maudslay. *Armament*: Upper deck, two 6″ 81 cwt. B. L. R.; ten 5″ 36 cwt. B. L. R.			
UNARMORED.—*Gun vessels.*			
DOLPHIN[2]	925	520	870
Dates: Commenced building Oct. 10, 1881; launched Dec. 9, 1882; completed June, 1884. *Where and of what built*: At Dixon & Co.'s, Middlesborough-on-Tees; composite. *Maker of engine*: Hawthorn. *Armament*: Upper deck, two 6″ 81 cwt. B. L. R.; two 5″ 36 cwt. B. L. R.			
WANDERER[2]	925	520	870
Dates: Commenced building Oct. 10, 1881; launched Feb. 8, 1883; completed June, 1884. *Where and of what built*: At Dixon & Co.'s, Middlesborough-on-Tees; composite. *Maker of engine*: Hawthorn. *Armament*: Upper deck, two 6″ 81 cwt. B. L. R.; two 5″ 36 cwt. B. L. R.			
UNARMORED.—*Gunboats.*			
ALBACORE	560	310	770
Dates: Commenced building Sept. 2, 1881; launched Jan. 13, 1883; completed Mar., 1884. *Where and of what built*: At Laird's, Birkenhead; composite. *Maker of engine*: Laird. *Armament*: Upper deck, two 5″ 36 cwt. B. L. R.; two 4″ 22 cwt. B. L. R.			
MISTLETOE	560	310	770
Dates: Commenced building Sept. 2, 1881; launched Feb. 7, 1883; completed July, 1884. *Where and of what built*: At Laird's, Birkenhead; composite. *Maker of engine*: Laird. *Armament*: Upper deck, two 5″ 36 cwt. B. L. R.; two 4″ 22 cwt. B. L. R.			
WATCHFUL	560	310	770
Dates: Commenced building Sept. 2, 1881; launched Feb. 13, 1883; completed May, 1884. *Where and of what built*: At Laird's, Birkenhead; composite. *Maker of engine*: Laird. *Armament*: Upper deck, two 5″ 36 cwt. B. L. R.; two 4″ 22 cwt. B. L. R.			
UNARMORED.—*Special-service vessels.*			
SPHINX (special-service steamer)	1,130	630	1,140
Dates: Commenced building Aug. 26, 1881; launched Nov. 28, 1882; completed Oct., 1883. *Where and of what built*: At Green's, Blackwall; composite. *Maker of engine*: Penn. *Armament*: Upper deck, one 6″ 81 cwt. B. L. R.; six 4″ 13 cwt. B. L. R.			
DART (screw yacht)	470	280	200
Dates: Purchased in Mar., 1882; completed Nov., 1882. *Where and of what built*: Barrow Ship-building Company, Barrow-in-Furness; of wood. *Maker of engine*: Barrow Ship-building Company. *Armament*: Upper deck, two 9-pdr. 8 cwt. M. L. R.			

[1] Reclassified as a corvette in July, 1883.
[2] Reclassified as a sloop in May, 1884.
[3] Estimated.
[4] Constructor's estimated speed, with forced draught.
[5] Contract price.

Majesty's dock-yards and by contract since April, 1860, *&c.*—Continued.

Length between perpendiculars.	Breadth, extreme.	Draught of water (sea-going). Forward.	Draught of water (sea-going). Aft.	Speed at normal draught of water.	Capacity for coals.	Complement.	Estimated first cost of vessels building in Her Majesty's dock-yards and in private yards. Hull (inclusive of fittings).	Engines (inclusive of fittings).	Total.	Total cost of hull and engines of vessels building in Her Majesty's dock-yards and in private yards, when completed. Hull (inclusive of fittings).	Engines (inclusive of fittings).	Total.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Knots.*	*Tons.*		£	£	£	£	£	£
200	38	[3]12⅜	[3]15½	[4]13. 0	400	159	54, 220	[4]13, 150	67, 370	Incomplete.		
200	38	[3]12⅜	[3]15½	[4]13. 0	400	159	50, 864	[5]13, 350	64, 214	51, 941	16, 103	[6]68, 044
200	38	[3]12⅜	[3]15½	[4]13. 0	400	159	50, 864	[3]13, 350	64, 214	51, 259	15, 984	[6]67, 243
157	32	[3]11½	[3]14½	[7]11. 3	135	110	25, 850 4, 160	9, 800	[3]35, 650 [4], 160	31, 869	10, 708	[6]42, 577
157	32	[3]11½	[3]14	11. 3	135	110	25, 850 3, 920	9, 800	[3]35, 650 [3], 920	31, 620	10, 665	[6]42, 285
135	26	[3]9½	[3]11½	[7]10. 75	95	62	17, 650 2, 690	8, 500	[3]26, 150 [3]2, 690	21, 432	9, 019	[6]30, 451
135	26	[3]9½	[3]11½	[7]10. 75	95	62	17, 650 2, 710	8, 500	[3]26, 150 [3]2, 710	21, 990	8, 970	[6]30, 960
135	26	[3]9½	[3]11½	10. 75	95	62	17, 650 2, 705	8, 500	[3]26, 150 [3]2, 705	21, 346	9, 020	[6]30, 366
200	32	10½	10½	12. 5	230	94	31, 750 3, 400	15, 150	[3]46, 900 [3], 400	36, 660	15, 875	52, 535
133	25⅛	10⅛	12½	8. 8	64	51	9, 900		[3]9, 900	2, 910	606 [3]9, 900	13, 416

[4] Liable to revision when the accounts are finally closed.
[5] Purchase money.
[7] Speed deduced from trials of sister-ship.
[8] Estimated cost of completing for sea in dock-yard.

Statement of the armored and unarmored ships laid down to build in Her

Names.	Tons displacement.	Tons weight of hull.	Indicated horse-power.
1882-'83.			
ARMORED.—*Barbette ships.*			
BENBOW	10,000	6,640	9,500
Dates: Commenced building Nov. 1, 1882; estimated to be completed July, 1886, by contractors, and by dock-yard nine months later. *Where and of what built*: Building at Thames Iron Works, Blackwall; of steel. *Maker of engine*: Maudslay. *Thickness of armor plating*: On sides, 18″; bulkheads, 16″; barbettes, 14″ and 12″; conning tower, 12″ and 9″; armor tubes, 12″; screen bulkheads, 6″; decks, 3″ and 2½″; skin plating, 1″. *Backing*: Teak, 15″ to 12″. *Armament*: Barbettes, two 16.25″ 100 ton B. L. R. Upper deck, ten 6″ 89 cwt. B. L. R.			
CAMPERDOWN	10,000	6,640	9,500
Dates: Commenced building Dec. 18, 1882; estimated to be completed Dec., 1887. *Where and of what built*: Building at Portsmouth; of steel. *Maker of engine*: Maudslay. *Thickness of armor plating*: On sides, 18″; bulkheads, 16″; barbettes, 14″ and 12″; conning tower, 12″ and 9″; armor tubes, 12″; screen bulkheads, 6″; decks, 3″ and 2½″; skin plating, 1″. *Backing*: Teak, 15″ to 12″. *Armament*: Barbettes, four 13.5″ 64 ton B. L. R. Upper deck, six 6″ 89 cwt. B. L. R.			
HOWE	9,700	6,390	9,500
Dates: Commenced building June 7, 1882; estimated to be completed Dec., 1886. *Where and of what built*: Building at Pembroke; of steel. *Maker of engine*: Humphrys. *Thickness of armor plating*: On sides, 18″; bulkheads, 16″; barbettes, 11¾″ and 10″; conning tower, 12″ and 9″; armor tubes, 12″; screen bulkheads, 6″; decks, 3″ and 2½″; skin plating, 1″. *Backing*: Teak, 17″ to 10″. *Armament*: Barbettes, four 13.5″ 64 ton B. L. R. Upper deck, six 6″ 89 cwt. B. L. R.			
UNARMORED.—*Partially protected sloops.*			
PYLADES[1]	1,420	780	1,500
Dates: Commenced building Jan. 1, 1883; launched Nov. 5, 1884; estimated to be completed Mar. 31, 1885. *Where and of what built*: At Sheerness; composite. *Maker of engine*: Laird. *Armament*: Upper deck, fourteen 5″ 36 cwt. B. L. R.			
UNARMORED.—*Gun vessels.*			
ACORN[2]	970	530	850
Dates: Commenced building Oct. 16, 1882; launched Sept. 6, 1884; estimated to be completed Apr., 1885, by contractors, and by dock-yard in 1885-'86. *Where and of what built*: Milford Haven Company, Pembroke dock; composite. *Maker of engine*: Maudslay. *Armament*: Upper deck, eight 5″ 36 cwt. B. L. R.			
MARINER[2]	970	530	850
Dates: Commenced building Jan. 8, 1883; launched June 23, 1884; estimated to be completed Mar., 1885. *Where and of what built*: At Devonport; composite. *Maker of engine*: Hawthorn. *Armament*: Upper deck, eight 5″ 36 cwt. B. L. R.			
REINDEER[2]	970	530	850
Dates: Commenced building Jan. 15, 1883; launched Nov. 14, 1883; completed Jan., 1885. *Where and of what built*: At Devonport; composite. *Maker of engine*: Hawthorn. *Armament*: Upper deck, six 5″ 36 cwt. B. L. R.			
UNARMORED.—*Special service vessels.*			
STORMCOCK (twin screw sea-going tug)	568	255	1,210
Dates: Purchased in Sept., 1882; completed Nov., 1883. *Where and of what built*: At Laird's, Birkenhead; of steel. *Maker of engine*: Laird.			
ÆTNA (paddle tug)	530	250	970
Dates: Commenced building Oct. 23, 1882; launched Sept. 1, 1883; completed June, 1884. *Where and of what built*: At Laird's, Birkenhead; of steel and iron. *Maker of engine*: Laird.			
METEOR (paddle tug)	530	250	900
Dates: Commenced building Oct. 23, 1882; launched Sept. 5, 1883; completed Aug., 1884. *Where and of what built*: At Laird's, Birkenhead; of steel and iron. *Maker of engine*: Laird.			

[1] Reclassified as a corvette in July, 1883. [2] Reclassified as a sloop in November, 1884.
[6] Constructor's estimated speed, with natural draught.
[8] Purchase money. [9] Speed deduced from trials of sister-ship.

Majesty's dock-yards and by contract since April, 1880, *&c.*—Continued.

Length between perpendiculars.	Breadth, extreme.	Draught of water (sea-going).		Speed at normal draught of water.	Capacity for coals.	Complement.	Estimated first cost of vessels building in Her Majesty's dock-yards and in private yards.			Total cost of hull and engines of vessels building in Her Majesty's dock-yards and in private yards when completed.		
		Forward.	Aft.				Hull (inclusive of fittings).	Engines (inclusive of fittings).	Total.	Hull (inclusive of fittings).	Engines (inclusive of fittings).	Total.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Knots.*	*Tons.*		£	£	£	£	£	£
330	68½	[2]26½	[2]27½	[4]16.0	1,200	455	472,000	107,000	[5]579,000	Incomplete.		
330	68½	[2]26½	[2]27½	[4]16.0	1,200	445	475,000	[5]104,900	579,900	Incomplete.		
325	68	[2]26½	[2]27½	[4]16.0	1,200	445	440,000	[5]103,000	543,000	Incomplete.		
200	38	[2]12¾	[2]15¾	[4]13.0	400	159	52,020	[5]16,500	68,520	Incomplete.		
167	32	11⅜	14½	[4]11.0	150	100	27,500	14,500	[5]42,000	Incomplete.		
167	32	11⅜	14½	[5]11.0	150	100	37,000	[5]11,750	48,750	Incomplete.		
167	32	11⅜	14½	[5]11.0	150	100	35,000	[5]11,750	46,750	33,850	12,655	[7]46,505
152½	25	[2]8½	[2]10½	.....	120	.....	23,000		[5]23,000	23,000		[5]23,000
128	25	[2]10½	[2]10½	[2]12.0	80	.....	12,250	12,750	[5]25,000	12,831	13,244	[7]25,775
128	25	[2]10½	[2]10½	12.0	80	.....	12,250	12,750	[5]25,000	13,055	12,819	[7]25,874

[1] Estimated. [4] Constructor's estimated speed, with forced draught. [5] Contract price.
[7] Liable to revision when the accounts are finally closed.

Statement of the armored and unarmored ships laid down to build in Her

Names.	Tons displacement.	Tons weight of hull.	Indicated horse-power.
UNARMORED.—*Special service vessels*—Continued.			
WAVE (screw yacht)..... *Dates*: Purchased in Nov., 1882; completed Apr. 25, 1884. *Where and of what built*: Seath's, Glasgow; of wood. *Maker of engine*: Kincaird, Donald & Co. *Armament*: Upper deck, one 6 pdr. S. B.	320	140	800
HANDY (screw barge for gun trials)..... *Dates*: Commenced building July, 1882; launched in 1883; completed in 1883. *Where and of what built*: Armstrong & Co.'s, Newcastle-on-Tyne; of iron. *Makers of engine*: Armstrong & Co.	508	190	310
FIREQUEEN (screw tender)..... *Dates*: Purchased in March, 1883; completed July, 1883. *Where and of what built*: Leith; of iron. *Makers of engine*: Walker, Henderson & Co.	446	220	390
1883-'84.			
ARMORED.—*Barbette ships.*			
ANSON..... *Dates*: Commenced building Apr. 24, 1883; estimated to be completed Sept., 1887. *Where and of what built*: Building at Pembroke; of steel. *Maker of engine*: Humphrys. *Thickness of armor plating*: On sides, 18"; bulkheads, 16"; barbettes, 14" and 12"; conning tower, 12" and 9"; armor tubes, 12"; screen bulkheads, 6"; decks, 3" and 2½"; skin-plating, 1". *Backing*: Teak, 15" to 12". *Armament*: Barbettes, four 13½" 64-ton B. L. R.; upper deck, six 6" 89 cwt. B. L. R.	10,000	6,640	9,500
UNARMORED.—*Protected steam cruisers.*			
MERSEY..... *Dates*: Commenced building July 9, 1883; estimated to be completed March, 1886. *Where and of what built*: Building at Chatham; of steel. *Maker of engine*: Humphrys. *Armament*: Upper deck, two 8" 13-ton B. L. R.; ten 6" 89 cwt. B. L. R.	3,550	2,010	6,000
SEVERN..... *Dates*: Commenced building Jan. 1, 1884; estimated to be completed in 1887-'88. *Where and of what built*: Building at Chatham; of steel. *Maker of engine*: Humphrys. *Armament*: Upper deck, two 8" 13 ton B. L. R.; ten 6" 89 cwt. B. L. R.	3,550	2,010	6,000
UNARMORED.—*Gun-vessels.*			
RACER[1]..... *Dates*: Commenced building Apr. 9, 1883; launched Aug. 6, 1884. Estimated to be completed March, 1885. *Where and of what built*: At Devonport; composite. *Maker of engine*: Hawthorn. *Armament*: Upper deck, eight 5" 36cwt. B. L. R.	970	530	850
MELITA[1]..... *Dates*: Commenced building July 18, 1883; estimated to be completed in 1885-'86. *Where and of what built*: Building at Malta; composite. *Maker of engine*: Malta yard. *Armament*: Upper deck, eight 5" 36 cwt. B. L. R.	970	530	850
UNARMORED.—*Torpedo cruisers.*			
SCOUT..... *Dates*: Commenced building Jan. 8, 1884; estimated to be completed June 29, 1885, by contractors, and dock-yard in 1885-'86. *Where and of what built*: Building by J. & G. Thomson, Glasgow; of steel. *Maker of engine*: Thomson. *Armament*: Upper deck, four 5" 36 cwt. B. L. R.	1,430	750	3,200
UNARMORED.—*Dispatch vessels.*			
SURPRISE..... *Dates*: Commenced building Feb. 14, 1884; launched Jan. 17, 1885; estimated to be completed May 30, 1885, by contractors, and dock-yard in 1885-'86. *Where and of what built*: Palmer Ship-building Company, Jarrow-on-Tyne; of steel. *Maker of engine*: Palmer Ship-building Company. *Armament*: Upper deck, one 6-pdr. S. B.	1,400	780	3,000
ALACRITY..... *Dates*: Commenced building Feb. 14, 1884; launched Feb. 28, 1885; estimated to be completed June 30, 1885, by contractors, and dock-yard in 1885-'86. *Where and of what built*: Palmer Ship-building Company, Jarrow-on-Tyne; of steel. *Maker of engine*: Palmer Ship-building Company. *Armament*: Upper deck, one 6-pdr. S. B.	1,400	780	3,000

[1] Reclassified as a sloop in November, 1884. [2] Estimated. [3] Purchase money.
[4] Constructor's estimated speed, with natural draught.

Majesty's dock-yards and by contract since April, 1880, &c.—Continued.

Length between perpendiculars.	Breadth, extreme.	Draught of water (sea-going). Forward.	Draught of water (sea-going). Aft.	Speed at normal draught of water.	Capacity for coals.	Complement.	Estimated first cost of vessels building in Her Majesty's dock-yards and in private yards. Hull (inclusive of fittings).	Engines (inclusive of fittings).	Total.	Total cost of hull and engines of vessels building in Her Majesty's dock-yards and in private yards when completed. Hull (inclusive of fittings).	Engines (inclusive of fittings).	Total.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Knots.*	*Tons.*	.....	£	£	£	£	£	£
136	22½	7⅞	9½	.....	19	.....	6,000	2,002	[3]8,002	6,000	2,002	[3]8,002
115½	37½	[2]7⅞	[2]7⅞	9.0	6	.....	9,900	3,500	[4]13,400	10,908	3,952	14,860
157½	23½	[2]9	[2]12	11.3	60	.....	13,000		[3]13,000	9,420	5,347	14,767
330	68½	[2]26½	[2]27½	[5]16.0	1,200	454	475,000	[4]106,000	581,000	Incomplete.		
300	46	[2]16	[2]20	[5]17.0	750	250	106,500	[4]54,000	160,500	Incomplete.		
300	46	[2]16	[2]20	[5]17.0	750	300	106,500	[4]54,000	160,500	Incomplete.		
167	32	11⅛	[2]14½	[5]11.0	150	100	36,800	[4]11,750	48,550	Incomplete.		
167	32	[2]11⅛	[2]14½	[5]11.0	150	100	30,000	To be made in Malta yard.	.....	Incomplete.		
220	34	[2]12½	[2]14½	[5]16.0	450	130	43,000	23,600	[4]66,600	Incomplete.		
250	32½	[2]13	[2]14	[5]17.0	400	60	36,375	29,680	[4]66,055	Incomplete.		
250	32½	[2]12	[2]14	[5]17.0	400	60	36,375	29,680	[4]66,055	Incomplete.		

[4] Contract price. [5] Constructor's estimated speed with forced draught.

Statement of the armored and unarmored ships laid down to build in Her

Names.	Tons displacement.	Tons weight of hull.	Indicated horse-power.
UNARMORED.—*Special service vessels.*			
IMOGENE (screw yacht) ..... *Dates*: Purchased in January, 1884; estimated to be completed July, 1884. *Where and of what built*: Barclay, Curle & Co.; of wood. *Maker of engine*: Barclay, Curle & Co.	[1] 460	220	420
1884-'85.			
ARMORED.—*Turret ships.*			
HERO ..... *Dates*: Commenced building Apr. 21, 1884; estimated to be completed March, 1887. *Where and of what built*: Building at Chatham; of steel. *Maker of engine*: Rennie. *Thickness of armor plating*: On sides, 12", 11", and 8½"; bulkheads, 11½", 11", and 10½"; turret, 12"; conning tower, 12" and 9"; decks, 2½" and 1⅝"; skin plating, 1". *Backing*: Teak, 13½" to 9". *Armament*: Turrets, two 12" 43 ton B. L. R.; upper deck, four 6" 89 cwt. B. L. R.	6, 200	4, 200	6, 000
UNARMORED.—*Protected steam cruisers.*			
FORTH ..... *Dates*: Commenced building Dec. 1, 1884; estimated to be completed in 1887-'88. *Where and of what built*: Building at Pembroke; of steel. *Maker of engine*: Hawthorn. *Armament*: Upper deck, two 8" 13-ton B. L. R.; ten 6" 89 cwt. B. L. R.	3, 550	2, 010	5, 700
THAMES ..... *Dates*: Commenced building Apr. 14, 1884; estimated to be completed in 1887-'88. *Where and of what built*: Building at Pembroke; of steel. *Maker of engine*: Penn. *Armament*: Upper deck, two 8" 13-ton B. L. R.; ten 6" 89 cwt. B. L. R.	3, 550	2, 010	5, 700
UNARMORED.—*Gun-vessels.*			
SWALLOW ..... *Dates*: Commenced building Jan. 1, 1885; estimated to be completed in 1885-'86. *Where and of what built*: Building at Sheerness; composite. *Maker of engine*: Rennie. *Armament*: Upper deck, eight 5" 36 cwt. B. L. R.	1, 040	560	1, 500
ICARUS [1] ..... *Dates*: Commenced building Aug. 18, 1884; estimated to be completed in 1886-'87. *Where and of what built*: Building at Devonport; of composite. *Maker of engine*: Barrow Ship-building Company. *Armament*: Upper deck, eight 5" 36 cwt. B. L. R.	990	530	1, 200
UNARMORED.—*Torpedo cruisers.*			
FEARLESS ..... *Dates*: Commenced building Sept. 22, 1884; estimated to be completed Feb., 1886, by contractors, and dock-yard in 1886-'87. *Where and of what built*: Building by Barrow Ship-building Company; Barrow-in-Furness; of steel. *Maker of engine*: Barrow Ship-building Company. *Armament*: Upper deck, four 5" 36 cwt. B. L. R.	1, 430	750	3, 200
UNARMORED.—*Gun and torpedo vessels.*			
CURLEW ..... *Dates*: Commenced building Jan. 5, 1885; estimated to be completed in 1885-'86. *Where and of what built*: Building at Devonport; of steel. *Maker of engine*: Penn. *Armament*: Upper deck, one 6" 89 cwt. B. L. R.; three 5" 36 cwt. B. L. R.	785	435	1, 200
LANDRAIL ..... *Dates*: Commenced building Jan. 5, 1885; estimated to be completed in 1886-'87. *Where and of what built*: Building at Devonport; of steel. *Maker of engine*: Penn. *Armament*: Upper deck, one 6" 89 cwt. B. L. R.; three 5" 36 cwt. B. L. R.	785	435	1, 200
UNARMORED.—*Special service vessels.*			
BANN (screw tank vessel) ..... *Dates*: Commenced building Jan., 1885; estimated to be completed in Jan., 1886, by contractors. *Where and of what built*: Building by Queenstown and Passage Docks Company, Cork; of iron. *Maker of engine*: Queenstown and Passage Docks Company.	250	108	120

[1] Reclassified as a sloop in November, 1884. [2] Estimated. [3] Purchase money.
[4] Constructor's estimated speed with forced draught. [5] Contract price.
Four first-class torpedo-boats have been ordered to be built for the navy since April, 1880, equal to boats,

Majesty's dock-yards and by contract since April, 1880, &c.—Continued.

Length between perpendiculars.	Breadth, extreme.	Draught of water (sea-going). Forward.	Draught of water (sea-going). Aft.	Speed at normal draught of water.	Capacity for coals.	Complement.	Estimated first cost of vessels building in Her Majesty's dock-yards and in private yards. Hull (inclusive of fittings).	Engines (inclusive of fittings).	Total.	Total cost of hull and engines of vessels building in Her Majesty's dock-yards and in private yards when completed. Hull (inclusive of fittings).	Engines (inclusive of fittings).	Total.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Knots.*	*Tons.*		£	£	£	£	£	£
159½	24½	[2]9½	[2]13	.....	58	.....	14,000		[2]14,000	11,489	5,914	[4]17,353
270	58	[2]22	[2]24	[3]15.5	650	250	293,000	[4]56,000	349,000	Incomplete.		
300	46	[2]16	[2]20	[3]17.0	750	300	100,000	[4]48,500	148,500	Incomplete.		
300	46	[2]16	[2]20	[3]17.0	750	300	100,000	[4]53,500	153,500	Incomplete.		
195	28	[2]11	[2]12	[3]13.5	280	82	33,000	[4]15,000	48,000	Incomplete.		
167	32	[2]11⅛	[2]14⅛	[3]12.5	150	100	36,300	[4]12,725	49,025	Incomplete.		
220	34	[2]12½	[2]14½	[3]16.0	450	180	40,250	23,250	[4]63,500	Incomplete.		
195	28	[2]10	[2]11	[3]14.0	250	90	28,500	[4]12,600	41,100	Incomplete.		
195	28	[2]10	[2]11	[3]14.0	250	90	28,500	[4]12,600	41,100	Incomplete.		
104	19½	[2]7	[2]7	7.5	18	.....	4,890	3,110	[4]8,000	Incomplete.		

[4] Liable to revision when the accounts are finally closed.
about 112 tons displacement, and tenders were received on 18th March, 1885, for 10 first-class torpedo.

SHIP-BUILDING PROGRAMME

[NOTE.—The particulars in this return

Number to be built.	Names.	Displacement.	Indicated horse-power.	Weight of hull.	Where to be built.	Length between perpendicular.	Breadth, extreme.	Draught of water. Forward.	Draught of water. Aft.	Whether to be built of iron, wood, or steel.
	IN DOCK-YARDS.	*Tons.*		*Tons.*		*Ft.*	*Ft.*	*Ft.*	*Ft.*	
1	New armor-clad[1]	.....	.....	.....	Portsmouth.					
1	New armor-clad[1]	.....	.....	.....	Pembroke.					
1	Torpedo ram	3,220	[2]5,500	2,010	Chatham	270	46	18½	19½	Steel
1	New "Scout" (torpedo cruiser)	1,600	[2]3,500	790	Devonport	225	36	12½	14½	Steel
1	New gun vessel ("Swallow" type).	1,040	1,000 [2]1,500	560	Sheerness	195	28	11	12	Composite.
	BY CONTRACT									
2	New armor-clads	10,470	[2]8,500	6,850	Tenders invited Feb. 26, 1885.	340	70	26½	27½	Steel
5	Belted cruisers	5,000	[2]7,500	3,000	Tenders invited Feb. 26, 1885.	300	56	19½	22½	Steel
6	New "Scouts"	1,600	[2]3,500	790	Messrs. J. and G. Thomson, Glasgow (ordered Feb. 27, 1885).	225	36	12½	14½	Steel
4	New gunboats (composite) of about 650 tons. Particulars not settled.									
10	First-class torpedo-boats	.....	.....	.....	Tenders received Mar. 18, 1885.	....	....	....	....	Steel

[1] Type not yet decided.

B. L. R....Breech-loading rifle.
M. L. R....Muzzle-loading rifle.

PROPOSED FOR 1885–'86.

have been corrected to March 18, 1885.]

Complement.	Coal capacity.	Speed at normal draught of water.	Thickness of armor plating.	Thickness and nature of backing.	Armament.	
					Turrets or barbettes.	Upper deck.
	Tons.	*Knots.*				
150	600	[2]17½	4½" to 3" on turtle-back deck.	Nil	Nil	Two 5" B. L. R.; eight 1" Nordenfelts; torpedoes.
140	475	[2]16	Thin water-tight deck	Nil	Nil	Four 6" guns on poop and forecastle; two 6" guns on upper deck; eight 1" Nordenfelts; torpedoes.
100	280	11½ [2]12½	Thin water-tight deck (partial).	Nil	.....	Eight 5" B. L. R. guns; machine guns; boat gun.
430	.....	[2]15½	On sides, 18"; bulkheads, 16"; redoubt, 18"; turret, 18"; conning tower, 14"; decks, 3".	6" teak..	2 110-ton guns in turret.	Twelve 6" B. L. R. on upper deck; twelve quick-firing guns, and twelve 1" Nordenfelts on spar deck; torpedoes; boat and field guns.
350	900	[2]17½	On belt, 10"; conning tower, 12"; horizontal, 2"; sloping part of deck, 3".	6" teak .	Nil	Two 9".2 18-ton B. L. R. and ten 6" B. L. R. on upper deck; six quick-firing and eight 1" Nordenfelts on main deck; two Nordenfelts in tops; torpedoes.
140	475	[2]16	Thin water-tight deck	Nil	Nil	Four 6" B. L. R. guns on poop and forecastle; two 6" on upper deck; eight 1" Nordenfelts; torpedoes.
....	.....	[2]19	.....	.....	.....	Five torpedo tubes; one Nordenfelt.

[2] Forced draught, speed, and power.

S. B....Smooth bore.

STATEMENT SHOWING TOTAL EXPENDITURE ON SHIP-BUILDING FROM 1865–'66 TO 1883–'84.

	£		£
1865–'66	1,116,198	1875–'76	1,613,218
1866–'67	1,014,406	1876–'77	2,121,960
1867–'68	1,000,749	1877–'78	[1]2,922,442
1868–'69	1,094,362	1878–'79	1,508,049
1869–'70	1,337,047	1879–'80	1,366,697
1870–'71	1,230,814	1880–'81	1,426,249
1871–'72	1,184,172	1881–'82	1,682,500
1872–'73	809,087	1882–'83	1,767,014
1873–'74	1,290,026	1883–'84	1,980,090
1874–'75	1,528,161		

[1] Includes 1,523,197l. out of vote of credit.

ARMORED AND UNARMORED TONNAGE, BUILT IN HER MAJESTY'S DOCK-YARDS AND BY CONTRACT AND PURCHASED, AND THE TOTAL NAVAL EXPENDITURE, FROM 1865–'66 TO 1883–'84, INCLUSIVE.

[The standard tonnage proposed in 1870 was: Armored, 12,000 tons; unarmored, 7,500. The far greater complication and increased speed and power in ships have increased the cost of production in labor and materials per ton since 1870 by 50 per cent.]

Year.	Armored tonnage (weight of hull).	Unarmored tonnage, including "protected" and "partially protected" (weight of hull).	Actual expenditure for Naval service.[1]		
			Effective.	Non-effective.	Total.
	Tons.	*Tons.*	£	£	£
1865–'66	11,538	4,351	8,517,119	1,387,623	9,904,742
1866–'67	7,453	6,113	8,527,797	1,416,427	9,944,224
1867–'68	13,568	13,855	9,464,500	1,432,371	[2]10,896,871
1868–'69	16,414	7,726	9,302,017	1,443,161	[2]10,745,178
1869–'70	21,460	8,713	7,976,286	1,533,369	9,509,655
1870–'71	15,962	4,569	7,957,205	1,713,133	[3]9,670,338
1871–'72	13,920	7,538	7,894,854	1,724,570	9,619,434
1872–'73	6,353	8,178	7,602,925	1,771,403	9,374,328
1873–'74	5,003	9,701	8,376,223	1,802,819	[2]10,179,042
1874–'75	8,457	8,023	8,060,010	1,846,504	10,506,520
1875–'76	14,276	5,440	8,853,173	1,869,451	10,722,624
1876–'77	11,448	12,782	9,152,357	1,887,571	11,039,928
1877–'78	[4]21,921	[7]14,289	10,435,442	1,910,906	[2]12,346,348
1878–'79	8,229	9,661	9,001,199	1,941,448	10,942,647
1879–'80	6,851	8,376	8,196,075	2,005,498	[2]10,201,573
1880–'81	8,525	8,290	8,055,875	2,059,300	10,115,175
1881–'82	10,026	8,584	8,363,392	2,079,026	10,442,418
1882–'83	11,321	8,596	8,590,499	2,067,811	[10]10,658,310
1883–'84	12,864	6,415	8,435,820	2,077,205	10,513,025

[1] Excluding the conveyance of troops and votes of credit.
[2] Vote of credit £1,500,000 additional.
[3] Vote of credit £2,875,000 additional.
[4] Vote of credit £750,000 additional.
[5] Vote of credit £250,000 additional.
[6] 14,808 tons purchased.
[7] 4,839 tons purchased.
[8] Vote of credit £1,750,000 additional.
[9] Vote of credit £375,000 additional.
[10] Vote of credit £1,125,000 additional.

Under "Navy non-effective services" are half-pay, military pensions and allowances, and civil pensions and allowances.

Taken from the statement of E. N. Swainson, Assistant Secretary to the Admiralty of May 28, 1883. (Reg. No. 1271), except for years 1882–'83 and 1883–'84.

For 1882–'83, from appropriation account with the report of the Comptroller and Auditor-General, Feb. 19, 1884.

For 1883–'84, from same of Feb. 24, 1885.

EXTRACTS

FROM THE

REPORT OF THE GUN FOUNDRY BOARD.

(Report of the Gun Foundry Board. February 16, 1884, organized by the President in accordance with an act of Congress approved March 3, 1883. Together with the Supplementary Report of December 20. 1884.)

The act of Congress approved March 3, 1883, under which the Gun Foundry Board was organized, calls for a report on the following points:

(1) Which of the navy-yards or arsenals owned by the Government has the best location, and is best adapted for the establishment of a Government foundry.

(2) What other method, if any, should be adopted for the manufacture of heavy ordnance adapted to modern warfare, for the use of the Army and Navy of the United States.

(3) The cost of all buildings, tools, and implements necessary to be used in the manufacture thereof, including the cost of a steam-hammer or apparatus of sufficient size for the manufacture of the heaviest guns.

The first question presupposes the establishment of a Government Gun Foundry, properly so-called, the establishment to be under the absolute control of the Government, and the details of all work to be supervised and directed by Government officers.

The answer to this question involves simply an expression of opinion as to the superior adaptability, for the purposes of a gun foundry, of any navy-yard or arsenal now owned by the Government.

The second question imposes no limitation, and calls upon the Board to suggest "any other method" (apart from a Government foundry, pure and simple) by which the purposes of the act of Congress can be achieved. The Board is evidently called upon to consider the subject of joint action between the Government and private parties for the accomplishment of a national purpose.

The Board decided that there were three points of view from which this subject should be considered, viz:

(1) That the Government should supplement the plants of some of the steel workers of the country with such additional tools and implements as would enable them to turn out finished steel cannon.

(2) That the Government should give contracts of sufficient magnitude to enable the steel workers of the country to supply the finished guns without its direct aid.

(3) That the Government should establish on its own territory a plant for the fabrication of cannon, and should contract with private parties to such amounts as would enable them to supply from the private industries of the country the forged and tempered material.

ENGLAND.

SOURCES FROM WHICH THE ARMAMENT OF ENGLAND IS SUPPLIED.

Previous to the year 1859 the Royal Arsenal of Woolwich was the only source from which the armament of England was supplied. The arsenal was a purely governmental establishment, in which there were several departments. The department of the Royal Gun Factories was always under the command of an officer of the Royal Artillery; and here all cannon for the army and navy were fabricated.

Since the year 1859, the Elswick Works at Newcastle-on-Tyne has been a source of supply on which the Government has drawn more or less for guns. The experience of the connection of the English Government with these private works bears directly upon the subject of joint action between a Government and a private firm.

The plant put up by the Government became the property of the private company at a nominal valuation, and the Government paid about £65,000 to break the agreement, besides paying an increased price on articles manufactured for it.

FRANCE.

SOURCES FROM WHICH THE ARMAMENT OF FRANCE IS SUPPLIED.

Previous to the Franco-German war of 1870, it was the custom in France to confide all matters relating to cannon to the artillery corps of the army and navy; aid from private sources was neither sought nor offered; much secrecy was observed in all things relating to the business of ordnance; admission to the Government foundries was obtained with difficulty, and the experimental ground at Gâvre, with rare exceptions, was closed to all applicants.

For army purposes, the gun factories at Bourges, Puteaux, and Tarbes supplied all demands, while for the use of the navy the foundries of Ruelle and of Nevers, and the gun factories attached to them, provided the entire armaments.

With the advent of the war came the proof that a close corporation, such as was constituted by the system heretofore adopted, could not work to the best advantage of the country; and, with the return of peace and the necessity of re-armament, came a revolution of ideas which has led the Government to modify its practice.

It was recognized that the Government must have under its control some establishments purely governmental; but that, in order to provide for all contingencies as well as to prevent official ideas from running too much in a groove, it was desirable to encourage private industries, so that a spirit of emulation might be excited by competition and a channel afforded through which new ideas and inventions might reach the national works. The adoption of this course was made the more imperative in consequence of the new departure in gun-metal, and this opened the way to the encouragement of the steel industries of the country.

The plan thus decided on has been consistently carried out. The Government gave assurances to the private companies which induced them to expend the funds necessary to erect new and suitable tools, both for the casting of the metal and the fabrication of the guns.

The result of this action can be appreciated by reference to the following list of private companies which are now employed in providing armaments for the Government:

STEEL MANUFACTORIES PRODUCING STEEL UP TO TUBES FOR 16-CENTIMETRE GUN:

Jacob Holtza & Co	Unieux (Loire).
Marrel Frères	Rive de Gier (Loire).
Société des Acieries et Forges de Firminy	Firminy (Loire).
Compagnie des Forges et Acieries de St.-Étienne	St.-Étienne.

STEEL MANUFACTORIES PRODUCING STEEL UP TO TUBES FOR 42-CENTIMETRE GUN:

Henri Schneider & Co	Le Creusot.
Acierie de la Marine	St.-Chamond.

PRIVATE COMPANIES HAVING PLANT OF GUN FACTORY:

Henri Schneider	Le Creusot.
Cail & Co	Paris.
Société des Forges et Chantiers de la Méditerrannée	Havre.
Compagnie de Fives-Lille	Fives-Lille (Nord).
Société Anonyme de Constructions Navales du Havre	Havre.
Acierie de la Marine	St.-Chamond.

STEEL MANUFACTORIES PRODUCING ARMOR PLATES:

Henri Schneider & Co. (forged steel)	Le Creusot.
Acierie de la Marine (compound)	St.-Chamond.
Marrel Fréres (compound)	Rive de Gier.
Chatillon et Commetry (compound)	Montluçon.

The compound plates are manufactured under the patent of Mr. Wilson, of Charles Cammell & Co., Sheffield, England.

All the gun-carriages for the navy and for the coast defense are made at private works.

The above lists illustrate the immense increase of resources that the Government has obtained by encouraging private industries, and they contribute an important historical chapter for the instruction of a Government about to provide an armament for its military services.

The following is the list of the Government works manufacturing for the army, viz:

(1) Fonderie de Canons à Bourges, in the center of France. At this place steel guns are made of 90 millimetres, 155 millimetres, 100 millimetres and 240 millimetres; also rifled mortars of 220 millimetres.

(2) Atelier de construction à Tarbes in the Hautes Pyrenées, in the southwest part of France. At this place steel guns are made of 90 millimetres, and 120 millimetres; also carriages for field and siege guns.

(3) Atelier de Construction de Puteaux, near Paris. At this place all the steel mountain and field guns of 80 millimetres are made; also siege guns of 120 millimetres, and the Hotchkiss revolving cannon for flank defense.

(4) Gun carriages, limbers, &c., are made at Government shops at Vernon, Avignon and at Angers.

Gun-carriages are also manufactured for the army at private works.

Bourges.—The gun factories of the army fabricate no guns above the caliber of 24 centimetres, and it is only at Bourges that army guns of this caliber are constructed. At the private establishments mentioned above the work of fabrication has been carried as high as 34 centimetres, but the advantageous working capacity of the factories does not extend beyond the 24 centimetre gun.

Ruelle.—At the "Fonderie à Ruelle" all the constructive force of the marine artillery has been concentrated, and here all the largest guns are made. It contains the most remarkable collection of tools of the age. They are designed for guns of 34 centimetres and upwards, and have a capacity for handling guns of 160 tons in weight and 60 feet in length. The shop in which these tools are placed is about 450 feet in length and 131 feet in width, having a height of 85 feet at the central peak of the roof. At one end is the tubage pit, in which the gun tube is placed upright to receive the hoops. The bottom of this pit is at a depth of 85 feet below the floor. It is excavated in a rectangular form and is divided into four stories, contracting in area as the lower level is reached; at each story or landing place, the opening can be floored over to accommodate the work of hooping any length of tube. The heating furnaces are on the first story below the floor. The tools already in place are the following, but there is room for fully a dozen more of similar character:

Two turning lathes, capable of turning guns 15 metres long. These can be increased in length 10 metres.

Three boring machines for same.
One rifling machine for same.
Two smaller boring machines with adjustable connections for turning.
Two other machines for performing all the details of the work about the breech, for receiving the fermeture, turning the screw, slotting, piercing holes, &c.
Two movable cranes; one of 100 tons, the other of 30 tons capacity.

The contractors for these tools were Varall, Elwell & Middleton, Paris. The plant has cost millions of francs, and five years elapsed from the giving of the order to the setting up of the tools. A large portion of the time charged to the manufacture must be credited to the preparation of designs, no tools of their size and great capacity having been before conceived.

Taking the above short notice of the works at Ruelle in connection with what has been stated on the subject of private industries, it will be seen how well all the requirements are provided for a joint production of cannon by the Government and private parties. The latter assist up to a point justifying on their part a reasonable outlay of money for a plant, and the Government, though working in this common field as well, yet reserves to itself all the more onerous charges involved in the manufacture of the heaviest ordnance.

It seems as if in France the happy mean has been reached by which the Government and the private industries can work harmoniously towards the accomplishment of a national object.

In a combined system of this kind, it is very important to be assured that there exist mutual checks which act to prevent the one party imposing improper or hard terms on the other. The Board is not without evidence of the existence of these salutary checks in France.

A short time since the Government deemed it necessary to increase its armament by 300 additional guns, and decided that certain additional tests should be required of the metal for the tubes. When the provisions of the proposed contract were made known to the steel manufacturers, they resisted the requirements as being too hard and insisted on the acceptance of such steel as had been previously supplied; but to this the Government would not accede. Finding them determined in their resistance, the Government made inquiries abroad as to the possibility of securing the metal it required, and, finding that a foreign manufacturer would undertake the contract, a promise was given to him that he should receive the order. The steel manufacturers of France, hearing that the order was likely to be given to a foreign firm, endeavored to arouse a national feeling on the subject to constrain the Government to make the purchase in France, but to no effect; and they finally proposed to accept the Government proposition. But the minister had already given his word to the foreign manufacturer and the contract was lost to France. In this instance both parties, the Government and the private companies, acted within their independent rights, but neither could compel the other. This exhibition of effective counterpoise is a good proof of a happy adjustment of forces.

GERMANY.

With the exception of the small gun factory at Spandau, near Berlin, where a limited number of cannon up to 15 centimetres and some rifled mortars are fabricated, the source from which the armaments of Germany are supplied is the establishment of Mr. Fried. Krupp. The Government has no control over the works, consequently the principal dependence is on this private company. Owing to the great enter-

prise exhibited in the management, and to the support of the Government, the establishment has, for many years, enjoyed a monopoly of the manufacture of cannon for Germany, and it has been enabled to furnish guns to many other powers, notably to Russia.

The essential point to be observed in this short notice is that the main supply of the artillery of Germany is drawn from one private firm. In this respect the method differs from that followed either in England or in France. It goes without saying that the Government pays a high price for the manufactured article.

RUSSIA.

SOURCES FROM WHICH THE ARMAMENT OF RUSSIA IS SUPPLIED.

The Government of Russia has been an extensive purchaser of cannon from Mr. Krupp, at Essen; but, after adopting the Krupp gun for its armament, it proceeded to manufacture on that system for its own uses.

The course pursued to produce a supply from home manufacture was that of joint action between the Government and a private firm. The large steel works of Aboukhoff, near St. Petersburg, was the establishment with which the Government entered into partnership, becoming the owner of one-third of the stock. The Government is represented in the board of directors, the works are in the hands of the Minister of Marine, and Admiral Kolokoltzoff is the chief administrator or superintendent. At the commencement of the joint action the Government contributed largely to increase the plant by providing tools suitable for its work, and very substantial aid has been provided from time to time.

The substance of this statement was collected from parties with whom intercourse was held, who did not, in distinct words, condemn the practice under which the Government has been acting since it commenced to manufacture its own guns, but they evidently held the idea that the condition of affairs would be much improved if the Government had absolute control of the works. In order to achieve this object it was understood that the Government is soon to acquire such additional stock as will make it owner of about two-thirds of the whole. When this shall be accomplished it is thought that the Government will be able to produce its guns at less expense than is now incurred.

It was freely admitted that the material produced under this system of joint action has been at great cost, but the Government has reconciled itself by the conviction that the product was of first-class quality and better than could be procured from other sources at less expense. The ground is taken that, in a matter so important as armament, high price is not to be considered an obstacle to the possession of the best guns that can be produced, and the authorities believe they have attained this object in their manufacture.

This experience of the Russian Government in its joint action with the Aboukhoff Steel Works bears directly upon one of the most important points that the Board is required to consider, viz, "any other method," apart from a Government foundry pure and simple, by which cannon can be provided; and the results above cited demonstrate that in this combination in Russia, as in that between the English Government and the Elswick Ordnance Company, the Government must always expect to bear the loss.

The acquisition of additional stock may give the Government such control in the direction of the business of the works as to smooth the way to its possession of the whole. This seems to be the natural conclusion of the process now in operation, and its consummation would be a declaration of the practical failure of the plan inaugurated at the commencement. The experience of joint action between the Government and a private firm in Russia does not encourage the experiment in our own country.

Nearly the entire production of steel for cannon is distributed between the Aboukhoff Steel Works and the Kama, near Perm (in the Ural Mountains), but the product of the former is the more considerable. Among others, the Iznoskof and Alexandroff private steel works (both near St. Petersburg) manufacture projectiles, and as the Government diminishes its contracts abroad they will develop their plants to meet the demands for gun material.

THE UNITED STATES.

SOURCES FROM WHICH THE ARMAMENT OF THE UNITED STATES IS SUPPLIED.

Previous to and during the civil war the armaments of the United States were supplied from—

The Cold Spring Foundry, West Point, N. Y.
The South Boston Iron Works, Boston, Mass.
The Fort Pitt Foundry, Pittsburgh, Pa.
The Reading Iron Works, Reading, Pa.
The Builders' Iron Foundry, Providence, R. I.
The Phœnix Iron Company, Phœnixville, Pa.
The Ames Manufacturing Company, Chicopee, Mass.

Since the termination of the war the Fort Pitt Foundry has ceased to exist. The South Boston Iron Works Company has manufactured a few experimental guns, and with the West Point Foundry has executed some small orders of the Government in the conversion of cast-iron smooth-bores into rifle guns by inserting and rifling a coiled wrought-iron tube.

None of the companies mentioned above have ever made steel guns, and virtually the United States is destitute of a source from which such an armament as the age demands can be supplied.

GENERAL SUMMARY.

The foregoing presents the chief points of information that have been gained by the investigations of the Board.

As examples of a practical partnership between a government and a private company in working towards a national object the experiences in England and in Russia are very instructive, and warn against the adoption of such a system. In England, the Government, in addition to paying, during several years, very high prices for articles delivered, was forced to pay £65,000 to close an agreement; while the company, besides the profits on manufacture, came into possession of a complete working plant at a mere nominal valuation.

In Russia the Government finds itself involved with a stock company, paying excessive prices for what it receives, and discovers no way

of relief except by buying up shares and operating the establishment as a Government foundry.

As an example of depending almost entirely on private works Germany is a perfect instance. The works of Mr. Krupp are practically the sole source of supply of the German artillery. In such a case the Government must be the slave of the corporation, and subject to its whims, caprices, and conveniences. It needs no argument to show the dependent condition of the Government under such a rule; it might prove a source of the greatest embarrassment. The Board is well informed that some ten or eleven years ago the artillery officers were very restive under this load, and were making strenuous efforts to be relieved from it, but without success. It is hardly to be supposed that time has quieted the feeling of dissatisfaction.

As an example of depending alone on Government works France was a perfect instance before the Franco-German war. During the period referred to the Government foundries were the sole source of supply of the armament of the country; the officers charged with the work formed a close corporation; their action was never exposed to the public; their ideas were never subjected to criticism; the ingenuity and inventive talent of the country were ignored and resisted, and no precaution was thought necessary to provide a supply in case of need of re-armament. The result is well known; a great crisis came; the Government works were inadequate to meet the additional demands made upon them, and the patriotic efforts of private establishments were inadequate to produce all the material that was needed. How entirely France has now altered her system is shown in a previous part of this report; her present practice is theoretically perfect, and it has proved to be practically efficient. Her Government establishments are still retained, but as gun *factories* simply, in which the parts are machined and assembled, but for *foundry* work she depends upon the private industries of the country, and many of these works have found it to their profit to establish gun factories which supplement the Government factories to a great extent.

The conclusions of the Board on this subject accord with the plain teachings of these historical instances. It accepts the system now pursued in France as the proper standard for imitation, and recommends that in inaugurating the manufacture of war material in our own country a conformity as close as circumstances will admit to the plans which have proved so successful in France should be observed.

Having reached this conclusion, the Board is now prepared to dispose of the propositions into which, as stated on the seventh page of this report, the second interrogatory in the act of Congress was divided.

The first proposition was thus presented, viz:

> That the Government should supplement the plants of some of the steel workers of the country with such additional tools and implements as would enable them to turn out finished steel cannon.

The adoption of this proposition would involve the Government in the embarrassments which now exist in Russia, and which we have seen were so costly to the English Government in its partnership with the Elswick Ordnance Company.

The Board does not approve of such joint action.

The second proposition was thus presented, viz:

> That the Government should give contracts of sufficient magnitude to enable the steel workers of the country to supply the finished guns without its direct aid.

This proposition, if adopted without any qualification, would make the Government dependent entirely upon the private industries of the

country, which might combine to the detriment of the public service. The Government would have no guard against extortion and would be powerless against a combination. An actual instance of such a combination is cited in a previous portion of this report as having taken place in France, but the independent position of the Government made the effort futile.

The Board does not approve of this proposition taken by itself.

The third proposition was thus presented, viz:

That the Government should establish on its own territory a plant for the fabrication of cannon, and should contract with private parties to such amounts as would enable them to supply from the private industries of the country the forged and tempered material.

This proposition is approved by the Board and is regarded as the foundation upon which our system of manufacture should be built up. If this be done, and the Government made secure by the possession of works of its own, there is every reason to adopt in addition the idea embodied in the second proposition in order to *supplement* the Government establishments.

A state, with any pretensions to military power, should provide itself with factory facilities on a sufficient scale to perform the work of establishing standards, making experimental guns, and fabricating cannon on a moderate scale; but it is not considered judicious to concentrate in the Government establishments all the work of fabrication or to include within their operations the preparation of such material as can be provided by the private industries of the country. In the case under consideration the purchase of the steel required for cannon will stimulate our own manufacturers and interest them in the operations of the Government.

The Board is thus led to the conclusion that it is not advisable to embark in the establishment of a gun *foundry*, properly so called, but that it is more judicious to establish gun *factories*, and to purchase the material from our manufacturers.

At present the steel manufacturers of our country are not prepared to produce the material required for the larger calibers, and the important question arises, what means shall be adopted to induce them to study the subject and embark in the manufacture on a large scale. They cannot be expected to do this at a sacrifice of their own interests. This object can only be achieved by holding out a fair prospect of ultimate remuneration for the expenditures necessary to undertake the work, and this can only be done by the action of Congress.

It may be added that although the manufacture of armor plates for ships and fortifications was not referred to this Board for investigation, the erection of plant for providing modern cannon would go far towards reducing the outlay requisite to enable our great steel manufacturers to meet another pressing want of the Government.

The chief expense to be considered by private parties is that of the *forge*, but by the substitution of the hydraulic press for the hammer economy will be consulted and better results obtained. The Board is unanimous in approving the use of the press for all forging purposes; and recommends it to all who may embark in the manufacture of gun metal for the Government.

In conclusion the Board submits its replies to the three interrogatories contained in the act of Congress:

(1) Which of the navy-yards or arsenals owned by the Government has the best location, and is best adapted for the establishment of a Government foundry?

The Board does not recommend the establishment of a Government foundry, properly so called, which shall provide for the manufacture of steel and the fabrication of cannon. It considers that every inducement should be offered to attract the private industries of the country to the aid of the Government in providing ordnance for the Army and Navy, and that the steel manufacturers should be called upon to provide the material.

The Board recommends the establishment of two gun factories under the control of the Government, and selects the—

Watervliet Arsenal, West Troy, N. Y., as the site for the Army, and the *Washington navy-yard, District of Columbia, as the site for the Navy.*

The Board is unanimous in recommending that the Army and the Navy should be provided with separate establishments. This has always been the custom in France, producing good results; the reverse has been the practice in England, producing bad results. Dissatisfaction from this cause has existed for many years in the English Navy, and the Admiralty has recently brought about a revolution in the system so far as the supply of gun-carriages is concerned, by obtaining from Parliament a separate and distinct appropriation with which it is providing the English Navy with the Vavasseur gun-carriage in opposition to the will of Woolwich.

In the administration of the War and Navy Departments of the United States, each service has charge and direction of its own distinct system of artillery; hence if but one gun factory be provided, its control must be placed in the hands of a mixed commission. This must lead to conflict of authority and to embarrassments of all kinds, in which the heads of Departments must necessarily become involved. A close scrutiny of the practical difficulties that would arise in conducting the affairs of a gun factory in such mixed interests develops obstacles that would be insuperable even with the most harmonious intent.

In the selection of the sites mentioned, it is not intended to convey the idea that they are regarded as in every way adapted for the purpose, but, as the scope for choice is limited, they are considered the most advantageous. The Board does not recommend the purchase of new sites, as this would open so wide a field for selection as to embarrass the question by arousing local interests throughout the country.

(2) What other method, if any (apart from the establishment of a Government foundry), should be adopted for the manufacture of heavy ordnance adapted to modern warfare, for the use of the Army and Navy of the United States?

With Government gun *factories* established for both the Army and the Navy, there will be still needed the hearty co-operation of the private industries of the country. This cannot be aroused unless there is held out to them a fair prospect of remuneration. The Board does not approve of a partnership in business between the Government and private firms. *All history warns against such a course.* But it does believe that joint, and at the same time independent, action between them can be made to work harmoniously towards the common national purpose. This can only be done by a permanent and liberal appropriation by Congress for the specific purpose of providing the country with modern artillery; which appropriation shall be a guarantee against loss to the companies who elect to undertake the work.

(3) The cost of all buildings, tools, and implements, necessary to be used in the manufacture thereof, including the cost of a steam hammer or apparatus of sufficient size for the manufacture of the heaviest guns?

In reply to this question the Board presents an abstract of the information already given, arranged in a convenient form for reference.

Approximate cost of plant for producing the tempered parts of guns up to 100 tons, ready for delivery at gun factory:

Casting	$250,000
Forging (hydraulic press)	150,000
Rough boring and turning	210,000
Tempering	50,000
Total	660,000
Additional cost if liquid compression be adopted	175,000

Approximate cost of plant for gun factories:

Guns up to 6-inch caliber	50,000
Guns from 6-inch to 12-inch caliber	150,000
Guns from 12-inch to 16-inch caliber	350,000
Buildings and shrinking-pit	350,000
Total	900,000

Though the act of Congress replied to in the above report is one of inquiry, the Board desires to emphasize the necessity of a proper encouragement to the private steel manufacturers, which shall insure the supply of gun material without loss to the Government or private companies; and is of opinion if Congress shall be pleased to appropriate an adequate sum for providing modern artillery for the Army and Navy, to be held in the Treasury to be expended under the authority of the President, that (with such a prospect of remuneration) there are steel manufacturers in the United States who will undertake the production of gun-metal on a large scale, on the sole condition that their steel shall meet the required tests.

The facts that the United States is destitute of the means of fabricating the modern guns so urgently needed for national defense, and that at least three years will be required to complete the tools, construct the shops and establish the plant, would seem to demand an immediate appropriation of the amount ($1,800,000) estimated for the establishment of the proposed gun factories.

SUPPLEMENTARY REPORT OF THE GUN FOUNDRY BOARD.

The Gun Foundry Board, reconvened by order of the Secretary of War, May 7, 1884, and the Secretary of the Navy, April 29, 1884, was directed:

1. To prepare plans and estimates for the preparation and purchase, both for the Army and the Navy, of plants for gun factories to complete guns from 6-inch caliber to 16-inch caliber, including buildings and shrinking-pit, and to report the full and detailed estimates for the cost of the work aforesaid.

2. To state whether the same can be better and more economically performed in establishments owned by the Government, or by private contract, or by a combined system whereby the said work can be accomplished partly by the Government and partly by private contract.

3. To make specific recommendations as to the best method of procuring steel for guns, and to indicate in what manner appropriations can most advantageously be made.

In accordance with its orders the Board met in Washington, D. C., May 15, 1884, and after due consideration appointed two committees, one composed of the army, the other of the naval members of the Board,

to prepare plans and estimates for gun factories for their respective services, and addressed a circular letter to the steel manufacturers of the United States, in order to procure opinions, based upon practical and business considerations, as to the best method of obtaining the required supply.

The Board has met with great difficulty in obtaining the desired information. No satisfactory replies having been received to its circular letter, the Board requested the assistance of Mr. James M. Swank, secretary of the American Iron and Steel Association, and by his efforts and interest a meeting was effected with leading representatives of steel manufacture, which has enabled the Board to indicate the terms on which the manufacture of steel for guns of large caliber may be inaugurated in the United States.

In conclusion the Board has to report:

1. The total cost of each gun factory will be about $1,000,000.

The Army Committee has restricted its estimate to the special tools for gun construction and to the erection of buildings, as indicated in the previous report of the Board, omitting such details as locomotives, cars, railway tracks, pipes for the transmission of power, crane tracks, boilers, engines, &c.

The estimate of the Naval Committee includes these auxiliaries, with the exception of locomotives and cars, which swell the estimate accordingly. The buildings proposed by the two committees differ in form and arrangement, as might be expected, for quite different sites and local conditions. A careful study of the two projects has convinced the Board that when the estimates are reduced to the same standard there will be no essential difference between them.

The estimates for the tools included in the above establishments are based upon the prices of such standard articles abroad, the Board not having been able to obtain satisfactory estimates for similar tools in this country.

2. The question whether the fabrication can be better and more economically performed in Government establishments, or by private contract, or by a combined system, has been carefully considered, and the Board has been unable to discover any reason to modify the unanimous opinion expressed in its report of February 16, 1884, "that it is more judicious to establish gun factories;" that there should be "two gun factories under the control of the Government," and "that the Army and Navy should be provided with separate establishments."

3. The Board repeats its unanimous opinion "that the steel manufacturers should be called upon to provide the material," and recommends—

I. An appropriation of not less than $15,000,000, one-half for the Army and one-half for the Navy, to remain available until expended; provided, however, that none of the money so appropriated shall be expended except in payment for steel accepted and delivered.

II. Proposals to be issued by the War and Navy Departments for bids for the supply of the steel required by each, rough-bored, rough-turned, tempered, and conforming to specifications. Said proposals shall divide the steel required into two lots. Each lot shall include all the parts for one-half of the number of guns of each caliber. Each bid must include all of a lot or lots. Each bidder shall agree to deliver yearly a specified quantity of each caliber, the time of delivery of the smaller calibers to commence at the expiration of not more than eighteen months, and that of the largest calibers at the expiration of not more than three years from the date of acceptance of the contract. Each bidder shall specify the price of the parts for each of the several calibers. This price

may be modified by the Government in equity, according to the current rates of labor and material.

III. Bids, to be considered, must be made by responsible parties, each of which shall certify and guarantee to erect in the United States a suitable plant capable of making all the steel required, and of finishing it, in accordance with the contract.

From personal intercourse with prominent steel makers in the United States, the Board is in a position to assert that proposals issued on the above basis will be responded to, but that it will be necessary to appropriate the entire amount recommended in order to induce *responsible* steel manufacturers to erect and complete the plants to produce the steel for the guns needed for the national defense.

The above proposition contains only such a guarantee as would be required by business men embarking in a new and expensive undertaking.

If Congress shall conclude to adopt measures for procuring the supply of guns required, it is essential that its attention should be called to the absolute necessity of appropriating at the same time the $2,000,000 needed for the factories in which the guns are to be fabricated.

As it will require at least two years to erect and equip the factories, and many causes of delay may arise, the appropriations for them should be made at the earliest moment, that as much time as possible may be allowed to perfect the arrangements.

It is appropriate to mention here that the annual expenses for operating the factories must be determined by the number of tools in use and the quantity of material fabricated, and be estimated for from time to time by the Departments. With this exception, the total estimate of $17,000,000 will complete the steel-producing plant, establish and equip the steel gun factories, supply the guns for six and one-half years, and inaugurate the manufacture of steel in large masses in the United States.

E. SIMPSON,
Rear-Admiral, U. S. Navy,
President of the Board.
E. O. MATTHEWS,
Captain, U. S. Navy.
T. G. BAYLOR,
Colonel of Ordnance, U. S. Army.
HENRY L. ABBOT,
Lieutenant-Colonel of Engineers,
Brevet Brigadier-General, U. S. Army.
SAMUEL S. ELDER,
Major, Second Artillery, U. S. Army.
W. H. JAQUES,
Lieutenant, U. S. Navy,
Member and Secretary of the Board.

WASHINGTON, D. C., *December* 20, 1884.

EXTRACT FROM THE REPORT OF THE NAVAL COMMITTEE OF THE GUN FOUNDRY BOARD.

The committee has made every effort to obtain information as to the ability of our home industries to produce gun tools, and confirms the statement of the Board, page 8 of its report, February 16, 1884, that "no

tools or implements" for the fabrication of such guns—*the "heaviest"*—as the act of Congress called for "have been manufactured or are in use in the United States."

While our own tool-makers signify, *in general terms*, their ability to make gun tools of any size and power, the foremost of them admit that much time will be required for the preparation of designs and patterns before they can produce tools equal in power, speed, and adaptability to those recommended by the Board.

It is evident, therefore, that if it is desired to provide the factory with tools within a reasonable time, at a reasonable cost, and with a certainty that they will be able to perform all the work that may be required of them, with a rapidity capable of producing the maximum results, this work must be *inaugurated* with tools of well-established reputation. In this connection it should be borne in mind there are but few firms in Europe who have reached a position of excellence in this specialty, and this has only been achieved after many years of experience and competition.

E. SIMPSON,
Rear-Admiral, United States Navy,
Chairman of Committee.
E. O. MATTHEWS,
Captain, United States Navy.
W. H. JAQUES,
Lieutenant, United States Navy.

EXTRACTS FROM THE REPORT OF COMMISSION ON NAVY-YARDS, DECEMBER 1, 1883.

MARE ISLAND NAVY-YARD, CALIFORNIA.

CONDITION OF PLANT.

Although neither in magnitude or completeness in correspondence with the relative importance which, from its geographical position, this yard assumes among the naval stations of the country, its mechanical departments are in fair working condition, and fully equal to the economical construction of wooden hulls, marine machinery of any size, the equipment and outfitting of the largest war vessels, excepting, of course, the specialties of manufacture not ordinarily made in such establishments.

Yards and docks.—There is a wooden floating dock, very much decayed, which is still in use, but near its end. A substantial stone dry-dock of large dimensions is in course of construction, and well advanced towards completion. When finished it will largely increase the facilities for repairs. There are no special means for the easy transportation of heavy weights, a source of inconvenience at all times, but, for obvious reasons, more serious during the rainy season. In other respects the plant of this department is in fair condition.

Construction.—Has its shops conveniently located, and they contain efficient machinery and appurtenances for all the work peculiar to such a department on wooden hulls and their accessories. It has neither tools nor appliances for the construction of hulls of metal.

Steam engineering.—The shops of this department are quite sufficient for any work likely to be required of them for some time to come. They are, however, most unfavorably located, being at one extreme edge of the improved portion of the yard, half a mile from the basin of the floating-dock, new dry-dock, and wharf shears for lifting heavy weights. The disadvantages of such a location are obvious. Some of the machine tools that have been sent here from other yards, where they formed part of the plant, are old and obsolete. The boiler shop is small, and therefore inconvenient. Additional tools of great capacity are en route for this shop, which will add largely to its resources.

Ordnance.—Has all the plant it needs unless an arsenal should be established on the Pacific coast.

PORTSMOUTH NAVY-YARD, NEW HAMPSHIRE.

CONDITION OF PLANT.

Yards and docks.—The floating-dock of this department is of sufficient capacity to lift and haul out the frigates of the Minnesota class. The dock and ways are in fair condition, but the caisson is worn out. In other respects this department, as to plant, is in good condition.

Construction.—Has all appliances and facilities for the building of a wooden hull of the first class, and supplying the outfits usual in this department. For ship-construction in metal its plant is incomplete.

Steam engineering.—The several shops of this department, with the

exception of the foundry, are in a state of readiness to commence the building of a marine engine and boilers, of large size. Its store-houses are widely separated, and remote from the shops.

Ordnance.—Has a shop and tools in much larger quantity than it has been called on to use for many years.

BOSTON NAVY-YARD, MASSACHUSETTS.

CONDITION OF PLANT.

Generally very complete for the class of work it has hitherto been employed on.

Yards and docks.—The stone dry-dock is the longest of the three on the Atlantic coast. It can take in the largest ship proposed by the Naval Advisory Board. Its boilers are old and in bad condition; its pumps of small capacity and antique type. Otherwise this department is in good condition for its work.

Construction.—This department is in excellent condition for the building and repairing of wooden hulls of the largest class, and all their outfits. For hull construction in metal it has a small supply of plant.

Steam engineering.—Engines and boilers of the largest class can be built promptly in the shops of this department. Its large machine tools are superior to those of their kind found in any other yard. Many of the smaller ones are much worn, or are of obsolete design. The minor shops are in good working order.

Ordnance.—Has a full supply of tools and mechanical appliances for its purposes, in good condition. Its store-house, magazine, gun and shot park capacity is sufficient.

THE NAVAL STATION NEAR NEW LONDON, CONNECTICUT.

It has no plant.

NEW YORK NAVY-YARD.

CONDITION OF PLANT.

Yards and docks.—This department is deficient in docking facilities, one of the very first requisites of a first-class yard. There should be at least two more dry-docks, and as large a wet basin as can be constructed within the limits of the Government property. The dry-dock is much out of repair and needs immediate attention. The department is deficient in storage accommodations for tools and materials, and many buildings are in need of repairs.

Steam engineering.—Excellent, with exception of boiler-shop, which is altogether inadequate.

Construction.—In fair condition for the building and repairing of wooden ships. For the construction of hulls in metal there is a fair supply of tools and appliances.

Ordnance.—Good, having a considerable amount of machinery.

LEAGUE ISLAND NAVY-YARD, PENNSYLVANIA.

CONDITION OF PLANT.

Very incomplete generally.

Yards and docks.—Has the facilities necessary for the present work, but has no dry-dock.

Construction.—This department, though well supplied with machinery and tools requisite for the construction of wooden hulls, is nev-

ertheless unable to build one, as no foundations on which to set up the frames have been prepared. As there is no dry-dock, the repairs to hulls at this yard are confined to the upper works, spars, and outfits. It has a small plant for iron-ship building, and could doubtless make repairs to the upper works and interior of an iron hull. Connected with the iron-plating shop, it has a small machine-shop, containing light machine tools, and its smithery is equal to the demands made upon it.

Steam engineering.—This department has an outfit of excellent tools in the machine-shop. The shop room is limited in area, but an engine of moderate size could be built and set up there. For new boiler work the facilities are very deficient; there are but few power tools for this class of constructions. The foundry is capable of producing castings in iron up to 5 or 6 tons weight.

Ordnance.—Has storehouses only; no plant, shops, or machinery.

WASHINGTON NAVY-YARD, DISTRICT OF COLUMBIA.

CONDITION OF PLANT.

Yards and docks.—Has all the equipment and appliances for its own work. Has no dry-dock.

Construction.—This department has conveniences for building wooden hulls of any size. The marine railway being of small capacity and power, and there being no dry-dock at this yard, the repair of large vessels is restricted to their upper works. It has a fine rolling mill for the manufacture of sheathing copper, and machines for the manufacture of sheathing nails and copper tacks, all in good condition. Its minor shops are in fair condition and ready for the performance of their special work.

Steam engineering.—Has full plant in excellent condition for the building of marine engines and boilers of the largest class.

Equipment.—The most important shops of this Bureau are found at this yard. They contain all the appliances for converting scrap iron or blooms into anchors of the largest size, and miscellaneous forgings of large dimensions. There is also a full and complete set of machinery for making the heaviest chain cables used in the service, and for testing them. A shop for the manufacture of ship's galleys, which is in good working order, is connected with this department.

Ordnance.—The larger part of the mechanical work of this Bureau is performed in the ordnance shops of this yard. The machine-shop and foundry are amply supplied with facilities in good condition. There is a large foundry for the casting of iron ordnance, which, however, has been but little used. In the laboratory are made all the fuses and primers used in the Navy, as well as all pyrotechnic work, such as rockets, night signals, &c.

NORFOLK NAVY-YARD, VIRGINIA.

CONDITION OF PLANT.

Generally good.

Yards and docks.—The extreme length of the dry-dock is 300 feet; it will not, therefore, take a ship of the Chicago class, the second in size of those laid down by the Naval Advisory Board. In other respects the plant of the department is in good condition.

Construction.—Is in good condition for the building of wooden hulls and their outfits of the largest size, though additional building-slips are needed. For iron-ship building it has not a sufficiency of plant.

Steam engineering.—Has plant and facilities for the construction of

marine engines and boilers of the largest class. Generally its minor shops are in good condition, and, excepting a copper shop, sufficient for its needs.

Ordnance.—Has no machine tools.

PENSACOLA NAVY-YARD, FLORIDA.

CONDITION OF PLANT.

Yards and docks.—The chief deficiency in the yard is the want of any means of docking vessels. The wooden balance-dock that once formed part of the plant of the yard was destroyed during the late war. The stone basin within which this dock floated when in use still remains in good condition, and it is proposed to use it for a like purpose with an iron sectional dock, four sections of which have been made and sent to the yard. Nothing has been done towards preparing these sections for use since their arrival at the yard, and if so prepared they would be of but little value, as their combined lifting power is but 1,400 tons, sufficient only to raise the smaller of the third-class vessels of the Navy. For its own purposes this department has sufficient plant.

Construction.—A ship's hull and outfits of wood can be built in this department, which possesses all the facilities in plant and machinery for so doing. For the construction of hulls in metal there are no appliances whatever.

Steam engineering.—This department is of limited capacity and unequal to the production of work above medium size. For such repairs as ships during their cruises ordinarily require, its facilities and possibilities are ample and sufficient.

None of the other departments have any plant.

KEY WEST NAVAL STATION, FLORIDA.

There are no docking facilities here for ships of war. The mechanical department includes shops and appliances sufficient to make all ordinary repairs to the machinery, and outfits of cruising vessels. The heavier parts of a marine engine could neither be produced or handled within it, as its tools and apparatus are of limited dimension and capacity.

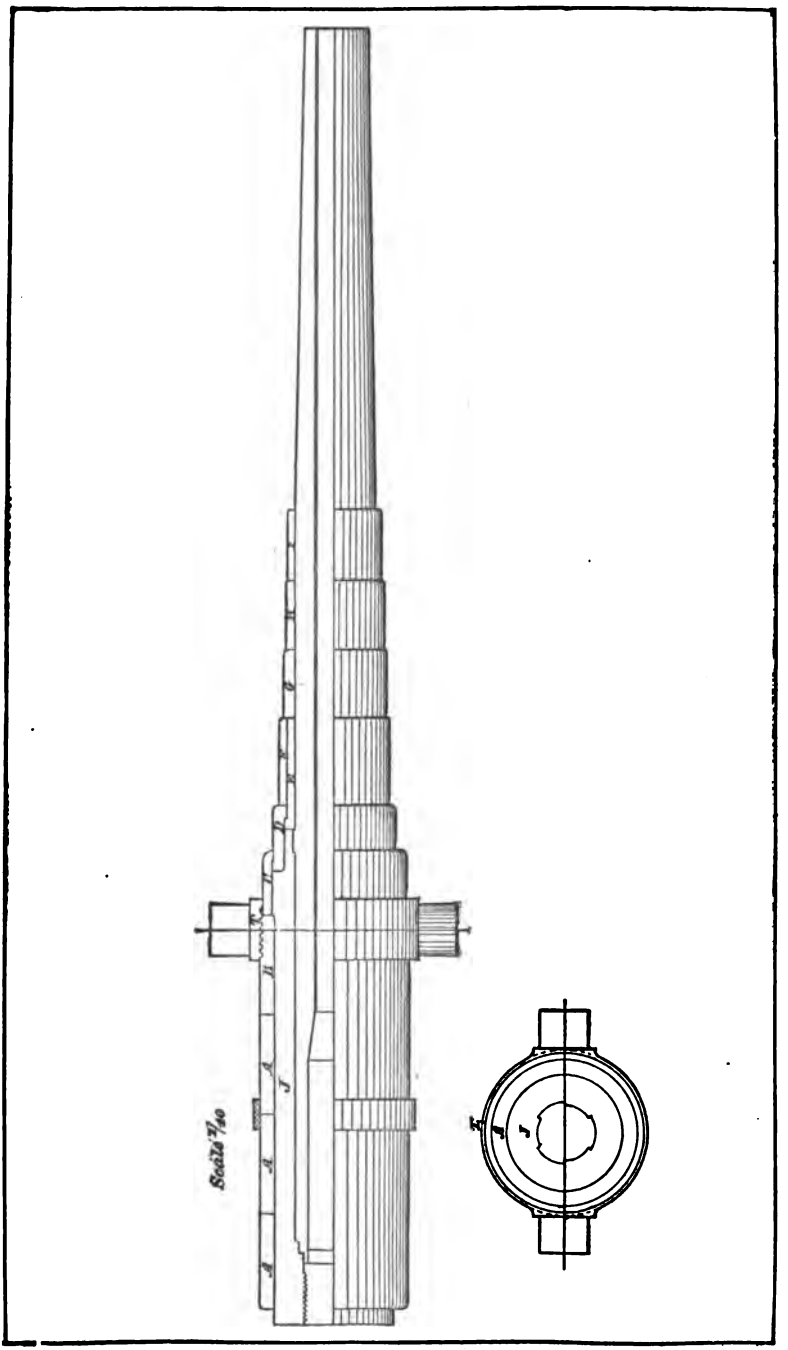
SACKETT'S HARBOR, NEW YORK, NAVAL STATION.

The situation at Sackett's Harbor is good, but there are three and a half acres only without plant, or improvements of any value.

NOTE.—A large part of the machinery is old and obsolete as far as economical production is concerned; while very little, if any, is adapted to the construction of modern steel ships or the fabrication of modern guns, excepting, perhaps, some of the tools now in use at the Washington navy-yard, where a limited number of 5, 6, 8, and 10 inch all steel rifles are being fabricated. The following table will give an idea of the guns on hand in various stages in October, 1885:

No.	Class.	Weight.	Caliber.	Length.	Powder charge.	Shell.
		Pounds.	*Inches.*	′ ″	*Pounds.*	*Pounds.*
2	Steel B. L. R	54,000	10	27 5.1	250	500
4	do	27,500	8	21 5	125	250
6	do	11,000	6	16 2	50	100
4	do	6,200	5	13 5	30	60

Plate 20.



8-INCH HOOPED B. L. R. BUREAU OF ORDNANCE, NAVY DEPARTMENT.

In addition there were being provided for them a full equipment of shot and shell, together with all the appliances for their service; ten 3-inch steel breech-loading howitzers; eight 8-inch gravity return hydraulic recoil check carriages for the Chicago, Atlanta, and Boston; twenty-one 6-inch of the same type for the above-named ships; two 5-inch, same type, for the Chicago; four mounts for Hotchkiss revolving cannon for the Dolphin; fourteen boat carriages for 3-inch breech-loading howitzers; ten directing-bar carriages for the same; annealing 12 steel bars for the War Department for the 10-inch Woodbridge wire gun, each bar 24 feet long, 4″ × 4″, weighing 1,290 pounds; the tube for this gun was also bored here for the War Department; three Howell torpedoes; rough boring and turning all the tubes and jackets for those 6-inch guns that are to be finished at West Point and South Boston.

The plant includes one modern lathe of 72-inch swing and 65-feet shears (capable of machining the tube for a 100-ton gun), and another of 48-inch swing and 10-feet shears for jackets and hoops; also an oil tempering plant for treating hoops, &c., for 8 and 10-inch breech-loading rifles, and shrinking-pits for assembling guns. Plate 20 represents an 8-inch forged steel rifle, fabricated at the Washington Navy-Yard. (Chairman.)

EXTRACTS FROM MEMORANDA OF THE NAVY-YARD COMMISSION.

We recommend a reorganization and concentration of the mechanical departments in every navy-yard, so that there shall be but one shop in each for the performance of the same class of work.

We also recommend such a concentration of work, that each of the several articles that form a part of the outfit of every ship shall be made in a single shop, to be established in such yard as may have the best facilities and conveniences therefor.

We recommend, further, that at each yard a central steam generating establishment be erected, which shall furnish steam for all motive power, and for heating purposes; a great reduction in the cost of fuel and of attendance will unquestionably be secured thereby, as well as greater convenience and efficiency.

MARE ISLAND YARD.

We consider it absolutely necessary that the Mare Island navy-yard be retained in full operation, it being the only workshop of the Government on the Pacific coast.

PENSACOLA YARD.

We advise that the Pensacola yard be closed.

NORFOLK YARD.

We advise that the Norfolk navy-yard be retained in first-class working condition.

WASHINGTON YARD.

We advise that the Washington yard be dropped from the list of navy-yards, but, under the designation of naval arsenal, retained in full working condition for the manufacture of specialties under the Bureaus of Equipment and Ordnance; sheet copper under Construction, and standard articles under Steam Engineering.

LEAGUE ISLAND YARD.

We recommend that League Island yard be closed, both as a yard and as a naval station, until plans have been prepared and approved for such a yard as the Department requested authority to construct and Congress authorized, and until the filling, the construction of the quay walls, and the gateways to the great ship-basin in the back channel are completed.

The present plans contemplate the construction of exactly what the Department declared it did not want, viz, another similar yard to those it then possessed, whereas the Department demanded authority to build a great iron-shipbuilding and iron-manufacturing yard only. This change of plan necessarily involves the expenditure of an enormous sum of money for improvements that are not required, as they exist in other yards. Such an expenditure cannot therefore be justified.

We consider the site too valuable and desirable to be abandoned, and do not believe that similar or equal accommodations can be procured elsewhere at a lower cost. We believe no better locality than the Delaware River can be found for the purpose for which the site was selected,

and therefore recommend the completion of this yard on the original basis; but we are also unanimously of the opinion that it is totally unfit for an ordinary or small yard, and that if the original plan is to be abandoned the island should be also.

NEW YORK YARD.

We advise that the New York yard be retained as a first-class yard, but that no further expenditures be made thereon, until plans for the full development of the yard shall have been prepared and approved. These plans should include the improvement of the Wallabout channel and the utilizing of the cob-dock for the purposes of a wet basin.

NEW LONDON NAVY YARD.

We advise that the New London yard be dropped from the list of navy-yards and naval stations, and the stores and material sent to other yards.

We recommend further that arrangements be made for the transfer of the Naval Asylum to the vacated site on the Thames.

BOSTON AND PORTSMOUTH YARDS.

Some differences of opinion exist in the Commission in regard to the disposition to be made of these yards. All agree that the navy-yard at Portsmouth is indefensible against a serious attack from a fleet of iron-clads armed with modern rifled ordnance, unless new and extensive fortifications should be erected for that purpose, the cost of which would be so enormous as to preclude the consideration of such an expedient. Even then it would be so vulnerable to attack, from a force landed to the eastward of the yard, that it would require for its defense an equal force. As a consequence we recommend that no further expenditures be made thereon for improvements of any kind.

All agree that it would be difficult to overestimate the importance of the Boston yard in time of war, and that it should be so improved as to utilize the water frontage to its utmost extent and at the earliest moment. No expenditures for fortifications would be required for its defense beyond those demanded for the protection of the city itself. All agree that any proposal to dispose of this magnificent property cannot be too strongly condemned. All agree that the rope-walk should be kept in operation, and that in view of this fact and of the superior quality of the painted canvas goods made at this yard, the sail-making department should be kept in operation for the manufacture of tarpaulins and other similar articles for the entire Navy.

A difference of opinion exists as to the immediate disposition to be made of these yards; two members believe that the yard at Portsmouth should be closed; one member believes that the yard at Boston should be retained in active operation; one member considers it important to keep Portsmouth navy-yard open for the reception and refitting of ships returning from southern stations; and that any repairs needed by wooden ships can be made there as well and as cheaply as at any other yard. But he concurs with the other members of the Commission that its importance and value for ship-building have passed away, and that it must be closed whenever the necessity for the repair of wooden vessels ceases. In case it should be decided that no necessity exists for a yard as a sanitary station, he recommends that it be closed. The same member and another believe that no necessity exists that would justify the use of the Boston yard as a construction and repair yard in time of peace.

EXTRACTS FROM MEMORANDUM OF NAVY-YARD COMMISSION.

TABLE No. 3.—*Tabulated statement showing area, cost of site, and improvements of each navy-yard and station; also present value of site, improvements, machinery, and personal property of each, June 30, 1882.*

Navy-yards, stations, and appurtenances.		Area.	Cost of sites.	Cost of improvements, including repairs.	Present value of sites.	Present value of buildings, miscellaneous improvements, machinery, and personal property. Neither cost nor present value of sites are included.				
Locality.	Property.					Buildings.	Miscellaneous improvements.	Machinery.	Personal property.	Total.
		Acres.								
Mare Island, Cal.	Upland	741	$883,491 00	$8,313,401 79	$144,820 00	$2,183,782 47	$2,006,862 97	$308,876 62	$36,243 22	$4,535,765 28
Do	Tule, or swamp	4,108								
New York, N. Y	Yard									
Do	Cob-dock	179½	426,713 15	11,642,687 11	7,720,000 00	3,322,022 80	2,632,303 39	584,307 34	37,720 64	6,576,354 17
Do	Naval hospital									
Do	Ellis' Island	4½	Mil'y res.		Mil'y res.					
Norfolk, Va	Yard	82½	40,401 00	7,859,682 33	825,000 00	1,980,486 88	2,429,113 00	322,895 38	24,173 46	4,756,668 72
Do	Saint Helena Island	41½	2,403 50		120,000 00					
Do	Fort Norfolk	5	Mil'y res.		50,000 00					
Do	Naval hospital grounds	71	3,000 00		497,000 00					
Do	Craney Island (part of)		Mil'y res.		Mil'y res.					
Boston, Mass	Yard	87½	171,336 52	7,568,973 20	4,736,080 87	3,387,722 44	2,369,416 29	1,038,594 18	37,542 54	6,833,275 45
Do	Ordnance grounds	30			90,000 00					
Do	Naval hospital, Chelsea	75			210,933 27					
Do	Niter depot, Malden	5½			14,897 52					
Washington, D. C	Yard	42	4,000 00	4,451,549 86	1,413,500 00	1,911,640 83	454,670 55	982,871 29	34,075 07	3,383,257 74
Do	Ordnance establishment, Belleview.	90	45,000 00		45,000 00					
Do	Naval hospital	A'b't ¾	7,914 50		7,678 00					
League Island, Pa	On island	580½	Gift.	1,741,836 03	546,625 00	613,054 93	78,000 00	241,540 53	21,160 51	953,755 97
Do	On mainland	37½								
Do	In Back Channel	306½								
Do	Ordnance establishment		Mil'y res.		Mil'y res.					
Portsmouth, N. H	Dennett's Island	58	5,500 00	4,314,241 54	9,125 00	1,158,335 82	2,051,243 59	425,455 50	25,249 48	3,660,284 39
	Seavey's Island	106	100,500 00							
Pensacola, Fla	Yard	83½	Mil'y res.	6,384,776 80	Nominal	680,968 12	1,644,337 45	93,575 51	13,689 23	2,432,555 31
Do	Ordnance establishment		Mil'y res.		Nominal					

TABLE No. 3.—*Tabulated statement showing area, cost of site, and improvements of each navy-yard and station, &c.*—Continued.

Navy-yards, stations, and appurtenances.		Area.	Cost of sites.	Cost of improvements, including repairs.	Present value of sites.	Present value of buildings, miscellaneous improvements, machinery, and personal property. Neither cost nor present value of sites are included.				
Locality.	Property.					Buildings.	Miscellaneous improvements.	Machinery.	Personal property.	Total.
		Acres.								
Pensacola, Fla	Naval hospital		Mil'y res		Nominal					
New London, Conn		86	Cond'l title	$170,632 66	Cond'l title	$38,084 90	$22,100 00	$740 45	$4,446 85	$65,372 20
Key West, Fla		2½	$10,400 00	85,293 84	$40,837 50	140,184 25	33,360 00	18,500 00		192,044 25
Coasters' Harbor Island, R. I.		90	Gift		Unknown					
Sackett's Harbor, N. Y		3½	4,425 00	40,651 73	Unknown					
New Orleans, La		22	15,000 00		Unknown					
Blythe Island, Ga		1,100	130,000 00	564 85	Unknown					
Blackbeard's Island, Ga		1,600	15,000 00		Unknown					
Grover's Island, Ga		350	7,500 00		Unknown					
				52,574,291 73		15,416,298 44	13,721,407 24	3,967,356 80	284,301 00	33,339,363 48

REMARKS.—The value of the various buildings, miscellaneous improvements, machinery, and personal property has been determined by an appraisal based upon the cost of reproduction by contract less the estimated deterioration, and not on auction values, and is believed to be substantially correct. The present values of the sites as given are the estimates of the proper officers of the various navy-yards only. Under the heading of improvements are included not only the yard buildings and improvements, but those of the ordnance, marine, and hospital establishments.

The present values of the sites could not be obtained without the employment of expert appraisers, which was not authorized. The figures given are those of the civil engineer of the yard, and can be considered as approximate only.

League Island was purchased by the city of Philadelphia for the sum of $400,620, and presented with an unconditional title to the Government for the purpose of a navy-yard. The naval hospital at Philadelphia being attached to the naval asylum, its cost, including repairs to date, amounting to $282,940.44, has not been included in the cost of the navy-yard establishment.

The site of the navy-yard at New London was purchased by the State of Connecticut for the sum of $23,119.28, and given for naval purposes only to the Government.

The navy-yard and appurtenances at Pensacola are situated upon a reservation originally made for naval and military purposes, which is of nominal value only.

Fort Norfolk, Craney Island, Ellis Island, and the site of the ordnance establishment of League Island, at Fort Mifflin, are military reservations transferred to Navy by the War Department.

Coasters' Island was presented to the Government by the city of Newport, R. I., for the purposes of a naval training-school, but with an unconditional title.

WHAT HAS BEEN DONE FOR A NEW NAVY.

The following extract from an address delivered by Rear-Admiral Simpson, before the Washington Branch of the United States Naval Institute, December 4, 1885, compactly summarizes what has been done toward a new Navy since June, 1881:

The first and most important consideration for a Navy is ships! A reference to our Navy lists shows a beggarly account. What encouragement have we for the future? We have much encouragement, and I will trace with historical precision the progress that has been made, slowly indeed but surely, in this direction.

The origin of the effort dates from June, 1881, when the Hon. William H. Hunt, Secretary of the Navy, appointed an Advisory Board to consider and to report on the need of appropriate vessels for the Navy. This board, styled the first Advisory Board, decided that for all purposes of "surveying, deep-sea sounding, protection and advancement of American commerce, exploration, the protection of American life and property endangered by wars between foreign countries, and service in support of American policy in matters where foreign governments are concerned," and for providing a "reserve of sufficient strength to maintain the effectiveness of the fleet," the United States Navy should comprise seventy unarmored cruisers.

The Board, in its report of November 7, 1881, stated that there were 32 vessels in the Navy fit for service. The required 38 vessels were classed as follows, viz:

Two first-rate steel double-decked unarmored cruisers, having a displacement of about 5,873 tons, an average speed of 15 knots, and a battery of four VIII-inch and twenty-one VI-inch guns; cost, $3,560,000.

Six first-rate steel double-decked unarmored cruisers, having a displacement of about 4,560 tons, an average sea speed of 14 knots, and a battery of four VIII.-inch guns and fifteen VI-inch guns; cost, $8,532,000.

Ten second-rate steel single-decked unarmored cruisers, having a displacement of about 3,043 tons, an average sea speed of 13 knots, and a battery of twelve VI-inch guns; cost, $9,300,000.

Twenty fourth-rate wooden cruisers, having a displacement of about 793 tons, an average sea speed of 10 knots, and a battery of one V-inch gun and two 60-pounders; cost, $4,360,000.

In addition to these cruisers it was recommended to build five steel rams of about 2,000 tons displacement and an average sea-speed of 13 knots; cost, $2,500,000.

Five torpedo gunboats of about 450 tons' displacement and a maximum sea speed of not less than 13 knots, and one heavy-powered rifled gun; cost, $725,000.

Ten cruising torpedo boats, about 100 feet long, having a maximum speed of not less than 21 knots an hour; cost, $380,000.

Ten harbor torpedo boats, about 70 feet long, having a maximum speed of not less than 17 knots per hour; cost, $250,000.

The Board stated that "iron-clads are absolutely needed for the defense of the country in time of war," but as its orders were to recommend means of providing for the present "exigencies of the Navy," it considered this type outside of the category of vessels it was ordered to consider.

In the naval appropriation bill approved August 5, 1882, authority was given to build one each of the first two types enumerated above, and an Advisory Board (the second) was provided to advise and assist the Secretary of the Navy in all matters relating to their construction, and "to prepare plans, drawings, and specifications of vessels, their machinery and armament, recommended by the late Naval Advisory Board not authorized to be built."

The second Advisory Board was organized November 13, 1882, previous to which there had been issued from the Navy Department notice and advertisements concerning the construction of the two steel cruisers, inviting "all engineers and mechanics of established reputation, and all reputable manufacturers of vessels, steam engines, boilers, or ordnance engaged in the business, all officers of the Navy, especially naval constructors, steam engineers, and ordnance officers, having plans, models, or designs of any vessels, or of any parts thereof, of the classes authorized by the naval appropriation act of Congress of August 5, 1882, to submit such plans, models, and designs

to the Naval Advisory Board directed to be organized by the Secretary of the Navy, under the provisions of said act, for his advice and assistance in designing and constructing said vessels, in order that the same may be examined by said Board in accordance with the provisions of said act."

The Board issued a circular November 25, 1882, suggesting the general features for the larger vessel authorized to be built for the guidance of those proposing to submit plans.

The Board recommended to the Secretary of the Navy, November 21, 1882, that, in addition to the two cruisers already authorized to be built, there should also be constructed two of the ten second-rate single-deck steel unarmored cruisers recommended by the first Advisory Board, also one dispatch boat.

On January 2, 1883, the Secretary of the Navy recommended to Congress (in accordance with the advice of the Advisory Board) the construction of one steel cruiser of about 4,000 tons displacement, three steel cruisers of about 2,500 tons displacement, one dispatch boat of 1,500 tons displacement, and one cruising torpedo boat to cost $38,000. The largest cruiser previously authorized was omitted for sufficient reasons, as she could not be built on the sum appropriated, and it was not considered judicious to build so large and expensive a vessel, which is not required, and which would be very expensive to retain in commission.

On February 1, 1883, the Board submitted general features for a 4,300 ton cruiser, and on Febuary 5, 1883, the Secretary of the Navy issued the same to ship builders and engine builders in the United States likely to make proposals for construction.

Congress, in the Naval Appropriation bill approved March 3, 1883, provided for the construction of one cruiser of 4,500 tons displacement (Chicago), two of 3,000 tons displacement (Atlanta and Boston), and one dispatch boat of 1,500 tons displacement (Dolphin), a portion of the estimated cost being voted at that time, and the balance being provided in the temporary half-year appropriation for the Navy approved July 7, 1884.

The Secretary of the Navy in his report of December 1, 1883, recommended, in accordance with the advice of the Advisory Board, the construction of seven additional steel vessels, viz.: one of each of the three types already under construction by the authority of Congress, and in addition to them, two heavy and two light armed gunboats. The consideration of a bill introduced in Congress in accordance with this recommendation produced an investigation by a Senate committee, the evidence given at which showed that, with the exception of two of the officers summoned, the Advisory Board had the confidence of the Navy.

This bill failed to pass the House of Representatives. The debate upon it in the Senate was very thorough and showed that, in that chamber, party lines were yielding to what was felt to be a national question.

In the act making appropriation for the Navy, approved March 3, 1885, Congress authorized the construction of four additional vessels, two of not less than 3,000 nor more than 5,000 tons displacement, costing, exclusive of armament, not more than $1,100,000 each; one heavily-armed gunboat of about 1,600 tons displacement, costing, exclusive of armament, not more than $520,000; and one light gunboat of about 800 tons displacement, costing, exclusive of armament, not more than $275,000. This bill was passed during the last hour of an expiring Congress, and a line introduced in the House provided that the construction of these vessels should be under the direction of the Navy Department, not subject to the supervision of the Advisory Board. The general features and preliminary plans and calculations have been made for these vessels by a special Board on additional vessels, and they are now in the hands of the Bureaus, who are preparing designs on which bids can be made if proposals are issued for their construction by contract.

We thus see that * * * whether with an Advisory Board or without an Advisory Board, the Navy can count on an addition of seven steel cruisers of modern construction and one dispatch boat as a nucleus for the new navy. The coming year will see four of these vessels completed, and it may be that the year following may launch the four additional vessels; and have we not a right to believe that, the inertia of rest being overcome and the energy of motion having been communicated, the pressure of the wave of public opinion will grow in force until it will come to be a recognized necessity to make a yearly appropriation for the increase of the Navy? I think we have a right to believe it.

THE FUNCTIONS OF SUBMARINE MINES AND TORPEDOES.

Under date of December 10, 1885, Lieut. Col. Henry L. Abbot, Engineer Corps, wrote to the chairman of the committee as follows:

"At your request I submit my views as to the true function of submarine mines and torpedoes in defending our coasts. To do this intelligibly it is necessary to consider briefly the whole subject of sea-coast defense.

"It is now universally admitted that armored ships of war can move past any ordinary land batteries with comparative impunity, provided the channel be unobstructed. To obstruct the channel, submarine mines are the most certain and prompt means known to modern science. They are, therefore, the first thing to be considered in preparing to close our great seaports against a maritime enemy.

"But submarine mines alone are easily attacked. If operated by electricity—and no other class can be used unless we are prepared ourselves to abandon the ocean—boat parties can land, seize the stations containing the batteries and operating apparatus, and thus render the whole system inactive. Forts secure against sudden assault are, therefore, essential to the system.

"But security against land assault is not enough. Without smaller flanking guns to keep boat parties from grappling the mines and cables, or destroying them by countermining with modern high explosives, an enemy could soon work his way through the dangerous zone. A heavy flanking fire of canister and case shot, and of machine guns, must, therefore, be provided to sweep the entire obstructed area. In our own system electrical arrangements are included, which deliver this fire automatically, and thus render it effective by night or in times of fog.

"But even this is not enough. If smaller guns alone are trusted to protect the mined area against countermining, an enemy would approach in safety with his heavy-armored ships, and with modern artillery would soon destroy our small guns and their emplacements at a distance from which we could make no reply. Hence, the most powerful guns, capable of piercing his armor at long ranges, and thus keeping him at a safe distance, cannot be omitted from our armament. Such guns are costly and restricted in number, and must, therefore, be protected against hostile fire by first-class iron-plated defensive works.

"In fine, then, submarine mines, small flanking guns to keep off boats, and heavy ordnance, mounted and properly covered, in modern sea-coast batteries constitute to-day the four essential elements of a vigorous defense.

"Certain auxiliaries are also important, although much less so than these four essentials. Such are the electric light to detect an enemy prowling among the mines, light-draught picket-boats to watch his approach at a point well in advance of our position, and movable torpedoes under electrical control from the shore, to assail him unawares when attempting to countermine.

"If, in addition to these means of closing the entrance to our vulnerable points of attack, we have a fleet of fast torpedo-boats, armed with Whitehead torpedoes and machine-guns, ready to cross our line of defense and assail the enemy when least expected, the approaches to our coast are rendered dangerous, especially at night, and he will be compelled to cover his armored fleet with a number of such torpedo-boats

superior to our own before making a determined attempt to enter our great seaports with a view to levying an immense contribution, or to working destruction upon our cities, our navy-yards, and our commercial marine.

"With such a system of coast defense as that sketched above we shall have ready an intrenched field of battle, which cannot be turned by an assailant, and where we shall have every advantage in future contests upon which much may depend.

"For less important channels offering less inducements to attack a mined area covered with less costly artillery in less elaborate defensive works, may be trusted to afford the needful protection, but for such cities as New York, San Francisco, Boston, Philadelphia, Baltimore, and New Orleans, it is ruinous economy to fail to prepare in season such defenses as the science of the age demands. The money will ultimately be paid to the enemy to purchase a disgraceful peace, instead of going to our own working population for what is necessary to maintain the national honor.

"Very respectfully, your obedient servant,

HENRY L. ABBOT,

"*Lieutenant-Colonel of Engineers, Brevet Brigadier-General, U. S. A.*"

PAPER

ON

NAVAL TORPEDO WARFARE.

[Prepared for the use of the select committee of the United States Senate on Ordnance and War Ships, by Lieut. W. H. Jaques, United States Navy, with papers by Lieutenant Commander F. M. Barber and Lieut. E. W. Very, United States Navy.]

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WASHINGTON, D. C., *January* 5, 1886.

GENTLEMEN: In accordance with your instructions I have the honor to submit the following information in relation to *naval* torpedo warfare, showing what attention torpedoes, torpedo-boats, and submarine artillery have received in the United States during the past five years, together with general descriptions of, and experiments with, the most advanced types, and the development of this arm in foreign countries since 1873.

Respectfully,

W. H. JAQUES,
Lieutenant, United States Navy.

To the Select Committee of the United States Senate on Ordnance and War Ships.

NAVAL TORPEDO WARFARE.

Congress is laboring under a most grievous error if it supposes that our torpedo system is efficient. In truth, it is wanting in almost every requisite of a useful and effective system; and were it efficient it must not be supposed that the most powerful torpedo system that could be conceived can take the place of all other defenses. Ships, both armored and unarmored, are indispensable to prevent blockade and to destroy commerce. The three lines—fortifications, torpedoes, and ships—are absolute requisites of a proper and sure defense, and heavy guns are imperative, not only for these ships, but to prevent countermining, removal, and destruction of the interior and channel torpedoes.

During the period from 1879 to 1885 very great progress has been made abroad in torpedo appliances.

An inspection of the annual reports of the chief of the Bureau of Ordnance, Navy Department, for these years will discover that many officers have kept themselves informed of the progress and development of torpedo warfare by study, by occasional opportunities afforded them to inspect foreign torpedo-boats and their apparatus, and by a chance observation of the trials of the same. But it will be further seen that very little advancement has been made by the United States Government in either offensive or defensive use of torpedoes; and that, as your committee witnessed in August, 1884, in Newport Harbor, we are still limited to a bag of powder or gun-cotton tied to the end of a short stick, hoping that the enemy will accidentally come near enough to be destroyed by it. An officer, saturated with torpedo information, once remarked, "Spar-torpedoes on a sea-going ship are about as useful as a Chinaman's banners, and not nearly so practical as his stink-pots."

As the type of modern heavy ordnance has reached a form to be accepted as a present standard, so has there been established a system of

torpedo defense upon which some definite action should now be taken if the United States Government does not want to find itself as far behind other powers in this important means of defense as it is in guns, armor, and ships. As yet scarcely any steps have been made in the right direction.

From 1880 to 1884, inclusive, but $295,000 were appropriated for the general expenses of the naval torpedo station in amounts so small that the general expenses could scarcely be met.

For general expenses torpedo station, Newport, R. I.

Fiscal year ending June 30—	Amount appropriated.	Fiscal year ending June 30—	Amount appropriated.
1880	$45,000	1884	$50,000
1881	95,000		
1882	45,000	Total	295,000
1883	60,000		

In 1880 the chief of the Bureau reported that "several aggressive torpedoes, which promise well, have been presented and trials will be made to ascertain their utility."

In 1881 he said that another movable torpedo had been experimented with, the results being encouraging; and further that "an improved form of the Lay torpedo (called the Lay-Haight) has been received and tried with favorable results, showing a very considerable reduction of weight and a gratifying increase of speed over those formerly purchased." Another movable torpedo was also experimented with with fair results.

This same year the Naval Advisory Board recommended five torpedo gunboats, capable of carrying a powerful bow gun, and twenty torpedo boats for harbor and channel service.

In 1882, at the Washington navy-yard, experiments were pursued with the rocket torpedo and valuable experience was obtained with the launching of torpedoes under water. The chief of the Bureau reported that—

> The introduction into the service of an efficient and practical auto-mobile torpedo is a matter of the greatest importance and urgency. Without such an arm we are behind all other nations, and could not maintain ourselves successfully when opposed to them in maritime war. The development of such a torpedo is slow, requiring long continued experiments and a great amount of time. As it cannot be evolved at once, there would be no time to perfect such an arm in the face of an emergency.
>
> Among the torpedoes of this nature which have presented themselves of late years the "Whitehead" is the only type which has met with decided favor among maritime nations, and has shown itself capable of working with any certainty at other than moderate ranges. As it is now adopted by all naval powers of any consequence, the inference is unavoidable that it must possess merit, and the United States should also acquire it. The proper way to do this is to purchase a limited number, with the working drawings, and then proceed to manufacture (and improve) as the needs of the service may require. An item has accordingly been inserted in the estimates for the purchase of the working drawing and twenty-five torpedoes of this type, that being the least number of the size desired that can be purchased.
>
> When used in the defense of harbors these torpedoes are launched from very light and swift boats, which are especially built for the greatest speed attainable. The construction of these boats is a specialty, and only a few firms in the world (and those abroad) have any considerable experience in building them. It would, therefore, appear very desirable that we should purchase one such boat from the best builder, and then use her as a model from which more could be constructed in this country. Accordingly an item for the purchase of a boat has been submitted in the estimates for next year.

The following were included in the estimates for the year 1884 for the Torpedo Corps:

Object.	Amounts estimated.	Amounts appropriated.
General expenses	$50,000	.....
For the purchase of auto-mobile torpedoes, of the latest construction, and a set of launching apparatus, with working drawings therefor (submitted)	100,000	.....
NOTE.—The United States has no practical auto-mobile torpedo suitable for general use in warfare afloat, and is the only nation of any pretensions which is not thus provided.		
For the purchase of a torpedo-boat and the working drawings of the same (submitted)	55,000	.....
NOTE.—The purchase of a fast torpedo-boat from one of the leading builders of the world will furnish our people with a type and example of the most advanced form of construction which is now available.		
Total	205,000	$100,000

In 1882 the Naval Advisory Board recommended "the purchase of one cruising torpedo-boat 100 feet long with a maximum speed of 21 knots," at an estimated cost of $38,000.

In 1883 the chief of the Bureau reported that—

Experiments have been continued at the Washington navy-yard on the rocket torpedo, and some experience has been gained.

The importance of having a sufficient number of light and very swift boats from which to launch offensive torpedoes is well known to the Department, and it is suggested that Congress be again urged to appropriate for one to be purchased abroad, from one of the firms which has most experience in the building of such vessels.

He also submitted an estimate of $55,000 for the purchase of such a torpedo-boat, and the working drawings of the same, with a note that—

The purchase of a fast torpedo-boat from one of the leading builders of the world will furnish our people with a type and example of the most advanced form of construction which is now available.

The Admiral, in his annual report for the same year, recalled the prominence that military authorities had given to torpedo defense, and said:

* * * Torpedo-boats are particularly necessary to drive off ships or to meet the torpedo-boats of an opposing force. Every foreign ironclad of any size carries from two to four torpedo-boats of from 50 to 60 feet in length, of great speed, and very formidable.

While we are mapping out a system for our Navy we should commence at once to build a class of torpedo-boats 100 feet in length that could not only help to protect our harbors, but could also operate off our coasts in moderate weather, for no torpedo-boats or torpedoes will be found very effectual in rough weather. The moral effect of such vessels will far exceed that of any submerged torpedoes.

You can scarcely enter a fitting-out port of one of the great powers where you will not see a number of these torpedo-boats steaming around, practicing on dummies prepared for the purpose, and showing their readiness at all times for action the same as if the nation was at war. They are considered as necessary for the defense of a harbor as forts or ironclads. * * * No ordinary steam-launch or tug would serve, as many people seem to think, the purpose of a torpedo-boat for harbor defense. Such a torpedo-boat must be large enough to fire a heavy charge, * * * have speed enough to escape from an enemy if pursued, and be impervious to Hotchkiss and mitrailleuse guns.

In this year also definite action was taken by Congress, and the sum of $100,000 was appropriated—

For the purchase and manufacture, after full investigation and test in the United States under the direction of the Secretary of the Navy, of torpedoes adapted to naval warfare, or of the right to manufacture the same and for the fixtures and machinery necessary for operating the same, one hundred thousand dollars; *Provided*, That no

part of said money shall be expended for the purchase or manufacture of any torpedo or of the right to manufacture the same until the same shall have been approved by the Secretary of the Navy, after a favorable report to be made to him by a board of naval officers to be created by him to examine and test said torpedoes and inventions.

In pursuance of this act, approved March 3, 1883, the Navy Department issued a circular to prominent inventors and manufacturers of torpedoes calling their attention to the act providing for the examination and test of torpedoes adapted to naval warfare, and appointed a board of five naval officers to conduct said examinations and tests.

Among those addressed were Messrs. Whitehead, Swartzkoff, and Berdan (foreign manufacturers), Capt. John Ericsson, Messrs. Asa Weeks, A. Rowe, and Thomas F. Rowland, Capt. J. A. Howell, U. S. N., the United States Torpedo Company, the Sims Electrical Fish Torpedo Company, and the Dynamite Projectile Company.

Public notices of the meetings of the Board were given by advertisement in the leading journals, and every opportunity possible was given to inventors and manufacturers to display the merits of their torpedoes.

The following detailed instructions were furnished the Board by the Bureau of Naval Ordnance:

BUREAU OF ORDNANCE, NAVY DEPARTMENT,
Washington City, December 3, 1883.

SIR: At the last session of Congress an act was passed and approved. * * *

It will be perceived from an examination of the circular what meaning the Department attaches to the expression "torpedoes adapted to Naval warfare," and this meaning must govern the Board in its proceedings.

It will also be seen that the Bureau did not undertake to inform inventors whether their torpedoes came up to the terms of the circular, but left that point to be decided by themselves in the first instance.

The undermentioned persons sent drawings to the Bureau and signified their intentions to present torpedoes before the board was organized: Mr. Asa Weeks, the American Torpedo Company, Commander J. A. Howell, U. S. N.

The Board having now been ordered, and informed that a vessel will be furnished from which to make the trials, the above-mentioned persons (and any others that may announce their desire to compete) will be directed by the Department to report to you with their apparatus; and you will observe that by the terms of the Bureau's circular, a certain reasonable amount of labor will be furnished by the Department (if necessary) for erecting the apparatus on shipboard.

Among the qualities that should be possessed by a torpedo adapted to naval warfare, the following appear to be most essential: Accuracy, range, velocity, certainty of operation, destructiveness, safety in handling, facility of handling, simplicity, and the ability, simplicity and efficiency of the launching apparatus.

The Bureau attaches very considerable importance to the last two of these qualities, for though a torpedo may be in itself adapted to naval warfare, if there is no practical means by which it could be efficiently, safely, and conveniently launched in the more important different directions desirable in a naval combat, this fact would detract very greatly from its usefulness; and if it could not be held conveniently in the launching position at sea, or be conveniently pointed, or be sheltered properly from the fire of the enemy's great guns and machine guns, until the ship that carries it should arrive within working range, it would fall short in a very important respect of being an effective weapon.

Of course a torpedo not well covered and even not very conveniently launched could be effectively used at night, in fogs, or in thick smoke, but for the general purposes of naval combat at sea it would be inadequate.

Among others the Board should note the following points:

Is the torpedo very difficult of manufacture, and is great accuracy of manufacture necessary in order to obtain uniform results?

Is great structural strength necessary?

What effect has the motion of the vessel at sea on the preparation of the torpedo, and on the torpedo itself when in position for firing, and what effect has the motion of the ship on facility of pointing?

Is the preparation of the torpedo for action an elaborate process, and while it is being handled and when in position for service are the vessel and her crew reasonably safe from injury?

Is much care necessary to keep the torpedo in a state for speedy use?

Is the actuating apparatus or material reasonably safe and harmless both when loaded and when in store; and does it probably deteriorate or dangerously change with time or with the changes of temperature and other conditions incident to service?

Can the torpedo be made innocuous (automatically) at the end of the flight?

Can it be conveniently and safely packed for transportation?

What is its probable price with launching apparatus complete?

Although to the diverse characteristics of the torpedoes that may be offered to the inspection of the Board, it is not possible for the Bureau to lay down any rigid rules for the conduct of the trial, the following programme is given as an example of what would seem to be a systematic investigation into the behavior of torpedoes on such a trial as it is the intention of the Department to hold, and the Board is expected to conduct its investigations in as nearly similar a manner as the circumstances of each case will warrant, the object being to bring out clearly the advantages and disadvantages of each system that is admitted to trial.

After an examination of the mechanical details of the torpedoes and the methods of carrying, loading, and launching them, the Board should proceed to the actual trial of those that they decide are adapted to use in warfare between ships at sea. In order that a correct idea may be formed of the character of the flight of each torpedo, and also of the distance at which practice should take place in the sea trials, some preliminary runs should be had in smooth water (against a target), either from the vessel (held in a fixed position) or from a wharf, float, or other convenient place.

In this way the readiness with which each torpedo starts, its most effective range, and the time of flight to that and to shorter ranges can be ascertained.

Having thus obtained the absolute and comparative ranges, velocities, accuracy, &c., under perfectly favorable conditions, it would appear best next to ascertain (in smooth water and without current) what deviation from the line of sight may be expected when the torpedoes are launched from a ship moving at speed past a fixed target at the range which has been decided upon as the most effective for each torpedo.

This experiment will probably bring out the deviations and errors of flight peculiar to each torpedo, unaffected by any other condition than the speed of the vessel. It is probable that information enough would thus be accumulated to enable the Board to proceed in an economical and efficient manner with the regular trials at sea, and these trials are the ones which are to finally determine the merits of the torpedoes.

The first point that it appears necessary to investigate is the effect of the sea on the flight of the torpedoes, and for this purpose position should be selected from which runs towards a target could be made, having the sea four points on the bow and on the quarter (and also abeam) of the torpedo while running, as well as directly against and with the flight, the vessel and target to be both in a state of rest.

The effect of the sea alone on the flight being thus recorded, it remains to ascertain the deviations due to launching the torpedoes in a sea-way from the vessel at speed against a target at rest, the object in this part of the trial being to get such a direction of sea as regards the line of the keel and the line of flight as will most clearly exhibit the directive force of the torpedo and operate most to throw it from the intended line of flight.

Perhaps the position that would best accord with the above design would be when running the ship with the sea four points on her bow, the torpedo being launched directly abeam and on the side from which the sea comes.

Thus circumstanced it appears probable that the deflective force of the sea running along the vessel's side, and the movements of the ship herself in rolling and pitching, would be about as unfavorable to accuracy as could well be obtained, unless running be found more unfavorable.

Those surface (or other) torpedoes that have detachable (or falling) magazines must be specially tested, in order to ascertain whether such magazines work certainly and properly.

It is of great importance to obtain the velocity and energy of the torpedoes at different points of the flight; and the striking energy at the working range is of essential importance, as it is a measure of the ability of the torpedo to break through the fence nets, &c. This last point must, if practicable, be determined by actual experiment.

When the runs are made from the vessel at speed, it will be necessary to observe carefully the direction of flight, as that duty will then offer more difficulty than in the other experiments.

In the case of subaqueous torpedoes, both in smooth and in rough water, every effort must be made to ascertain whether they hold a constant depth of submersion, and to value such oscillations as may occur. The steadiness of flight must be carefully observed on all occasions.

The proprietors or inventors of the torpedoes on trial are to be allowed to embark on the vessel and to be present at all trials of their own torpedoes. They will fully

explain the theory and construction of their torpedoes, and will each manipulate his own (with the exception of pointing and discharge), with such manual assistance from the crew of the vessel as may be necessary.

The description, size, and weight of each torpedo, and of its launching and preparatory apparatus, should be given; also, speed of vessel, height and direction of sea, wind, weather, &c., should be carefully noted.

In its report the Board will state distinctly whether in its opinion each torpedo examined is or is not adapted to warfare between ships at sea. It will also name those thus adapted (that it wishes to report favorable) in the order of their adaptation.

The Department desires it to be distinctly understood that every precaution must be taken to guard effectually the vessel and all those embarked in her against injury from the torpedoes and their appliances, and the Board will be especially careful to make all reasonable preparations for safety, and to allow no person (civilian or otherwise) to expose himself to serious risk.

I am, sir, your obedient servant,

MONTGOMERY SICARD,
Chief of Bureau.

Capt. G. E. BELKNAP, U. S. N.,
President Torpedo Board.

The Board held sessions at Milford, Conn., Norfolk, Va., and Washington, D. C., as well as in the waters of Hampton Roads and the Chesapeake, for the examination and test of the three types of auto-mobile torpedoes that were submitted to the Board. They were:

(1) The surface torpedo, presented by the American Torpedo Company, substantially a modification of the torpedo commonly known as the Lay-Haight, its motive power being carbonic-acid gas, acting upon a Brotherhood engine, and steered by electricity.

(2) The Weeks surface rocket-torpedo, presented by Asa Weeks, its motive power being a rocket.

(3) The Howell subaqueous torpedo, presented by Capt. John A. Howell, U. S. N., its motive power consisting of a steel fly-wheel revolving within a water-tight iron shell, set in rapid motion by the application of a jet of steam at high pressure.

The Board carefully examined all the torpedoes brought before it, and tested them as far as their distinctive features and the readiness of the competitors for the exhaustive trials required would admit.

In the presence of the Board there was but one trial of the torpedo presented by the Sim's Electrical Fish Torpedo Company, of New York.

The programme of trials as laid out in the instructions was not carried further than this one trial (smooth water), because the company was not prepared for any others, as the Board was informed by the company's representative.

The Board concluded as follows with regard to the adaptation of the presented torpedoes for naval warfare:

Qualities.	American Torpedo Company.	Weeks' rocket torpedo.	Howell torpedo.	Sims' Electrical Fish-torpedo Company's torpedo.
Accuracy	Good with reference to a fixed object in smooth water; not determined with reference to a target in rapid motion, nor in rough water where the seas might at times hide the course of the torpedo from the operator. The torpedo is steered by an electric current passing through insulated cables connecting the machine with the operator stationed either afloat or ashore as the occasion may require.	Lacking	Good	The torpedo is steered by an electric current passing through insulated cables connecting it with the keyboard, afloat or ashore. The working of the rudder was prompt and the torpedo obeyed her helm fairly well, but owing to the torpedo's length, large surface, and shape it was somewhat slow in turning.
Range	Good. The distance, at speed when the machine works well, being half a statute mile.	Insufficient and uncertain	Fair	Good; one mile of cable fixes the range of this particular torpedo.
Velocity	Fair, but other torpedoes, notably in Europe, surpass it.	Excellent, but very variable	Moderate	Poor; approximately 8½ knots.
Certainty of { a operation { b				
a. Certainty of launching and starting on its course.	Good, so far as tests not made in actual service at sea could show, but the Board regards the apparatus used as utterly unfit for the purpose in a sea-way under the conditions that naval warfare constantly imposes.	Good	Good	The torpedo was lowered from fixed tackles and towed into position. From its construction, however, the operation of launching from a vessel would necessarily be very difficult and awkward.
b. Certainty of explosive action on contact with target.	Undetermined. Plan submitted which would probably be efficient.	Undetermined by actual trial, but plans were presented for explosion on contact which would probably be efficient.	Undetermined. No firing system was presented.*	Undetermined. Plan for firing "at will" described, which would probably be successful in case operator made no mistake.
Destructiveness	Doubtful, as the efficiency of a surface torpedo as to destructive effect has yet to be shown by actual test.	Doubtful, as the efficiency of a surface torpedo as to destructive effect has yet to be shown by actual test.	It is a subaqueous torpedo and would probably be effective.	As the charge is subaqueous and large, the destructiveness is probably all that could be desired.
Safety in handling	Measurably safe, but the safety of a torpedo may be regarded as an utterly unknown quantity in a naval combat.	Measurably safe, but the safety of a torpedo may be regarded as an utterly unknown quantity in a naval combat.	Measurably safe, but the safety of a torpedo may be regarded as an utterly unknown quantity in a naval combat.	Measurably safe, but the safety of a torpedo may be regarded as an utterly unknown quantity in a naval combat.
Facility of handling	Awkward, owing to its length, bulk, and weight.	Good, but it has considerable length which may render it awkward when the vessel has much motion.	Good. The torpedo is very handy, being short and light.	Very awkward, owing to its length, bulk, and weight.

*The Board desires to correct its report by stating that a satisfactory firing-pin was submitted.—(Report Secretary of Navy, Vol. 1, 1884, p. 581.)

Qualities.	American Torpedo Company.	Weeks' rocket torpedo.	Howell torpedo.	Sims' Electrical Fish-torpedo Company's torpedo.
Simplicity	Complex	In design and construction it is very simple.	Simple	Fairly simple. The engine and steering compartment is readily dismounted for examination and repair, and readily assembled. As the power is generated outside, much complexity and many sources of accident are avoided in the torpedo itself.
Ability to be operated with safety from an enemy's fire.	Not good. Some exposure unavoidable, but under the conditions of naval warfare to-day, with the enormous powers of defense afforded by machine-guns of great range and power, torpedoes of great length, like the one in question, would prove dangerous to handle under the fire of an enemy.	Fair. Some exposure is unavoidable, but when once prepared the operator can withdraw to a place of safety.	Some exposure unavoidable. Plans for a shelter were submitted which would probably prove satisfactory.	Fair. Some exposure unavoidable, but under the conditions of naval warfare to-day, with the enormous powers of defense afforded by machine-guns of great range and power, torpedoes of great size, length, and weight would be dangerous to handle under the fire of an enemy. As this torpedo's charge is subaqueous, there would be no danger of its explosion by the enemy's fire after it was once launched.
Simplicity of launching apparatus.	No apparatus submitted that would answer the purpose in a sea-way, rendering the torpedo incomplete in that respect.	Good	Simple	None submitted, rendering the torpedo wholly incomplete in that respect.
Efficiency of launching apparatus.	See previous answer	Good as far as the mere operation of getting the torpedo into the water is concerned.	Good. Admits of rapid and easy training.	See foregoing answer.
Efficiency as to launching at an object.	See previous answer	As the launching apparatus is incapable of being trained, the pointing must be done by the helm of the vessel, which would usually entail considerable difficulty and sacrifice of maneuver.		See foregoing answer.

Questions.	American Torpedo Company.	Weeks' rocket torpedo.	Howell torpedo.	Sim's Electrical Fish-torpedo Company's torpedo.
Is the torpedo difficult of manufacture?	Not with proper plant	No	No	Not with proper plant.
Is great accuracy of manufacture necessary?	Yes; in certain parts of the mechanism.	No	No	Yes; in the electrical apparatus in the torpedo and on shore and in the cable.
Is great structural strength necessary?	No; except in the flask carrying acid, where great strength is required.	No	No	The connections between the float and the torpedo must be stiff and strong.
What effect has the motion of the vessel at sea on the preparation of the torpedo and in the torpedo itself when in position for firing?	Not determined, no opportunity for doing so.	Probably very little, but untried under such circumstances.	Probably very little on the preparation; not tried at sea, but probably very little.	Undetermined.
What effect has the motion of the ship on the facility of pointing?	Not demonstrated. In the case of this torpedo there could be none, as the pointing is done after the machine is launched.	Operates adversely, as the pointing has to be done by the vessel itself.	Less effect than on the pointing of a great gun, as the torpedo is easily trained, and elevation or depression are unimportant.	Not demonstrated, but in the case of this torpedo there could be none, as the pointing is done after it is launched and clear of the vessel.
Is the preparation of the torpedo for action an elaborate process?	It is very elaborate	No	No	No; on the contrary simple, except that it is large and heavy and awkward to handle.
While it is being handled and when in position for service are the vessel and her crew reasonably safe from injury?	Reasonably so at a long distance, but close aboard at operating range, the measure of safety would be exceedingly small. There would, of course, be great danger of explosion of either the torpedo charge or of the flask containing the carbonic acid gas from the effect of the enemy's machine guns.	Reasonably so at a long distance, but close aboard at operating range, the measure of safety would be small, as there would be danger of explosion of the charge by the enemy's machine guns.	Reasonably so at a long distance, but close aboard at operating range the measure of safety would be small, as there would be danger of explosion of the charge by the enemy's machine guns.	
Is much care necessary to keep the torpedo in a state for speedy use?	Several hours are required to charge the flask and get the torpedo ready for use, but when once ready it remains so as long as desired, within a limited time. A cruising ship would need an ice machine or other refrigerating or condensing apparatus in order to charge the flask, and the preservation of the liquid acid in steel flasks for any length of time would be attended with great danger to the vessel carrying it.	Very little	Very little	A fair amount of attention, such as would be necessary for any unused mechanism.

Questions.	American Torpedo Company.	Weeks' rocket torpedo.	Howell torpedo.	Sims' Electrical Fish-torpedo Company's torpedo.
Is the actuating apparatus or material reasonably safe and harmless both when loaded and when in store?	The sulphuric acid used in making the propelling gas must always be handled with great care. To attempt to carry the flasks charged, as would be necessary in time of war, would not be desirable, owing to great continuous strain on the the flask, changes of temperature, &c.	Yes	Yes	Perfectly safe and harmless.
Does it probably deteriorate or dangerously change with time or with the changes of temperature and other conditions incident to service?	The materials from which the carbonic acid is generated would not deteriorate.	Probably not	No	No, except that the cable might deteriorate in a warm or unequable climate.
Can the torpedo be made innocuous automatically at the end of the flight?	The inventor claims yes, and submits a plan which would probably be efficient, but no practical tests were possible, in the absence of any firing appartus.	The inventor claims yes; but as the plan involves the sinking or the loss of the torpedo, it was not tried.	The inventor claims yes, and submits plans which would probably prove efficient.	Yes.
Can it be conveniently and safely packed for transportation?	Yes, in parts	Yes	Yes	Yes; in parts, but some parts would be bulky.
What is the price, with launching apparatus complete?	The company states its price as $10,000 for each torpedo. No apparatus for launching at sea was presented.	Probable cost of torpedo and launching apparatus, without explosive, $150; but inventor would only sell the right to manufacture and use.	$1,000 for one complete with launching apparatus.	Not ascertained.

POINTS CONSIDERED BY THE BOARD.

American Torpedo Company.

1. This torpedo cannot be safely and conveniently controlled and launched in a sea-way with the apparatus supplied, the company itself declining to submit to such a test at sea, through fear of injuring the torpedo.

2. Unless arranged to fire from a shield, port, or turret, it could not be protected, before starting, from the fire of the machine guns of an enemy.

3. Its course could be seen as readily by an enemy as by those using it, and the fire of machine-guns would be immediately, and probably effectively, concentrated upon it for its destruction.

4. The propeller is not protected, and might readily foul itself with grass, sea-weed, or floating nets, &c., so as to render its action ineffective.

5. In the mêlée of battle the operating cables would be liable to displacement or fracture, and thus render the torpedo uncontrollable, and, therefore, useless.

6. That as compared with a well-known type of torperdo, the speed, so far developed by this torpedo, is insufficient. Its speed not exceeding 15 statute miles, or 13 knots per hour, it could not overtake any vessel going at that speed or even a slower vessel properly maneuvered to avoid it.

7. The range of half a mile against an object at rest though fair, could not be so regarded as against an enemy's vessel of even moderate speed, unless the enemy, through gross negligence, permitted the attacking vessel, armed with this torpedo, to place herself in a favorable position.

8. Vulnerability. This torpedo, moving at the surface at comparatively moderate speed, and, necessarily, at short range, is exposed to machine-gun fire, and a shot piercing any portion of the torpedo would disable it, every section containing some vital part.

9. That should the expander be put in action, and, meanwhile, the emergencies of battle interfere with the launching of the torpedo for a time, the speed of the torpedo would be very much reduced when finally launched.

10. Being a surface torpedo, the effect of its explosive action alongside an enemy is problematical. In

Week's rocket torpedo.

1. This torpedo possesses the advantages of simplicity, cheapness, and speed.

2. It is fatally defective in accuracy.

3. Its speed, at all times great, is very variable. This would seriously interfere in allowing for the change of position of a moving object or in firing across a current.

4. Its range is insufficent and very variable.

5. The torpedo could not well be arranged for firing from a launching apparatus capable of train, owing to its great length and the possible effects upon the ship herself of the products of combustion which are ejected from the rocket with great force towards the rear.

Finally, this torpedo is not, in the opinion of the board, adapted to naval warfare.

With regard to the other models of floating and spar torpedoes brought before the Board by Mr. Weeks, the Board is of the opinion:

1. That the floating torpedo is not a torpedo which would be of use in naval warfare.

2. That the spar torpedo, of which a full size model was exhibited and tried before the Board, is, in fact, no better than the spar tor-

Howell torpedo.

At the request of the inventor, the plan laid down for the experiments was:

1. To determine the effect of the "directive force" of the torpedo in securing accuracy of flight in the horizontal plane, both from the vessel at anchor and when underway at full speed.

2. To determine the uniformity of its submergence.

3. To determine its speed and range.

The experiments were to be tried in all kinds of weather at sea.

Points considered by the Board.

1. The horizontal accuracy due to the "directive force" was excellent, with the torpedo when fired from the vessel at anchor or under way and trained in various directions. The "directive force" inherent in this torpedo renders it unnecessary to make any allowance for the torpedo's being deflected on striking the waters, even when fired abeam from a vessel moving at speed.

2. The uniformity of submergence was not determined owing to the loss of the torpedo.

3. The speed as observed while making the experiments was not sufficient.

4. The extreme range observed was 1,500 feet, and the torpedo remained submerged throughout the entire distance.

5. The launching apparatus is simple, easy of manipulation, and so arranged that it can be readily protected from the fire of machine guns.

6. Being a torpedo of the subaqueous type its course cannot be seen by the enemy against whom it might be launched.

7. For the same reason its effect on striking a vessel at a proper depth would probably be fatal, even when carrying a moderate charge.

8. The propeller is fairly protected from fouling with sea weed, floating nets, &c.

9. While simple and comparatively inexpensive in construction; of light weight and readily stowed and handled; and showing great accuracy when launched

Sims' Electrical Fish Torpedo Company's torpedo.

With the data furnished by a single trial the Board is unprepared to give an exhaustive opinion on this torpedo, but it considers that enough has been shown to warrant the following:

1. It is from its size, shape, and weight cumbersome to stow, and very awkward to handle on board ship.

2. Its lack of speed would probably render it inefficient in combat between vessels under way. It could be seen and avoided by an enemy of moderate speed.

3. When operated in a seaway the combined surfaces of the float and torpedo would probably make it difficult to steer with accuracy.

4. Although the float is exposed to an enemy's machine-gun fire, it would not probably be injured by such fire.

5. In the mêlée of battle the cables would be liable to displacement and rupture, and thus render the torpedo uncontrollable and therefore useless.

6. While this torpedo embodies valuable features for harbor defense where it can be prepared and manipulated from the deck of a monitor or special vessel, the Board considers that its lack of speed makes its utility, even for this purpose, very doubtful.

Finally, in view of these considerations and conclusions,

POINTS CONSIDERED BY THE BOARD—Continued.

American Torpedo Company.

the opinion of the Board, a torpedo, to be effective, should be of the subaqueous type.

11. That the action necessary in turning on the expander, as at present arranged, is a great defect in the machine, the Board being of the opinion that such action should be automatic.

12. That from all previous experience and the experiments made in presence of the board with this type of torpedo, it sometimes fails, even after the most careful adjustments to operate properly, in the most unexpected and unexplicable manner.

13. While the single experiment at Milford, Conn., from the U. S. S. Speedwell under way, and at a speed of ten knots towards a target at anchor and in smooth water was successful, the board is doubtful as to its behavior in even moderately rough water. Its immersion being small the pitching motion under such conditions would be likely to throw both propeller and rudder out of water.

14. While the torpedo embodies valuable features for harbor defense where it can be prepared and manipulated from the deck of a monitor or special vessel, the board does not consider that, in its present development, and particularly as being a surface torpedo, it is well adopted even to that purpose.

15. A serious objection lies in the great length of time needed for filling the flask, with the alternative of storing the latter charged at an enormous pressure and incurring the risk of explosion through the phenomenon known as "fatigue of metals."

16. One operator at least must be exposed in order to watch the torpedo when dropped into the water from a vessel underway, nor can the engines of the torpedo be safely started until it is clear of the ship. Even then a mistake in steering the torpedo might be fatal to the vessel herself, while a failure to start promptly might cause the torpedo to foul the ship's screw, with disastrous results.

17. It would be necessary to have a reel of wire on board when firing from a vessel under way or the torpedo would be unmanageable. This would introduce a new source of accidents.

Finally, in view of these considerations and conclusions, the Board is of the opinion that this torpedo is not adapted to naval warfare.

Weeks's rocket torpedo.

pedoes already in use on board our ships-of-war, and they would therefore afford no fresh adaptation to the demands of naval warfare.

Howell torpedo.

***Points considered by the Board*—Continued.**

against an object; though not now developed to a point adapting it to naval warfare, yet in view of the good qualities which it seems to possess the Board is of the opinion that opportunity should be afforded the inventor for further experiment.

Finally, this torpedo is not, in the opinion of the Board, adapted to naval warfare.

Memoranda of trials of Howell torpedo.

1. Fired at right angles to the keel, and dropped from a point about 4 feet above the water. Vessel at anchor.

2. Pointed at an angle of 45° with the keel * * * apparently parallel to the original course. Vessel at anchor.

3. Speed, 9 knots * * * the direction appeared to be straight, but the final position showed that the torpedo had stopped about 15 feet to the left of the course. The range was not less than 1,000 feet. Vessel at anchor.

4. Results same as before except the speed in the first 100 feet was $9\frac{37}{100}$ knots. Anchor.

5. Fired from the vessel underway, estimated at 10 knots, and fired abeam when abreast the boat. The course was straight and the range, by estimation, was 800 feet.

6. Vessel at anchor. As to range * * * 530 feet.

[NOTE.—From examination of this trial the direction was good.—W. H. J.]

7. Vessel at anchor. The direction was excellent. The range, measured as before, was 1,015 feet. The speed for the whole distance was 9.3 statute miles, or 8.4 knots.

8. Vessel at anchor. The direction * * * was excellent. The range was not not measured, but was * * * about 30 feet greater than on a previous trial.

9. Vessel under way, about 10 knots. The direction was excellent. The range was about the same as in the two previous trials. The torpedo took the water in the crest of the bow wave. This was not strong or high and produced no apparent effect, the torpedo immediately disappearing beneath the surface as before.

10. Vessel under full way, making about 10½ knots. Fired the torpedo at right angles to the keel. The direction * * * was excellent. The range, as estimated, was 500 yards to the target. The torpedo, lying in the gangway, was shipped in the discharging apparatus and rigged ready for turning on steam in one minute and fifty seconds.

11. Vessel under full way, 10½ knots. Inventor thought that the torpedo had struck bottom at its first plunge.

12. Vessel under full way, 10½ knots. As to direc tion, * * * it was excellent. As to range and speed the torpedo ran about 400 yards in 2 minutes 5 seconds.

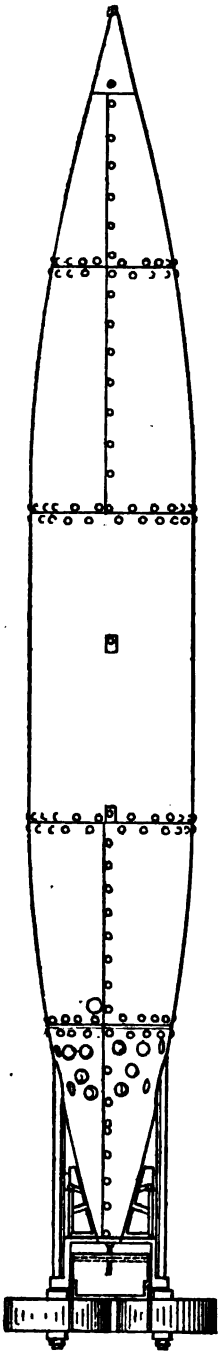
13. Fired at a net, to determine the depth at which the torpedo ran beneath the surface. The torpedo was lost. The cause of the loss is unknown to the Board; the case may have been injured and sunk by leakage; the torpedo may have stuck at the bottom, or may have risen to the surface unseen and been swept off by the tide, which was running a strong ebb.

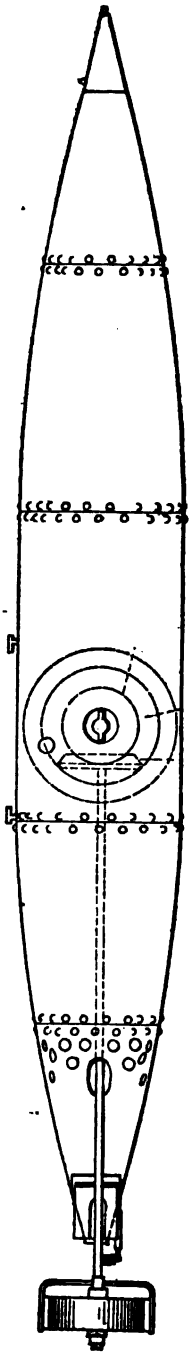
The single adjustment of the diving rudder made after the fourth trial was the only adjustment of any sort made during all the trials. The torpedo during these trials was dropped from a height of 7 feet above the water.

Sims' Electrical Fish Torpedo-Company's torpedo.

the Board is of opinion that this torpedo is not adapted to naval warfare.

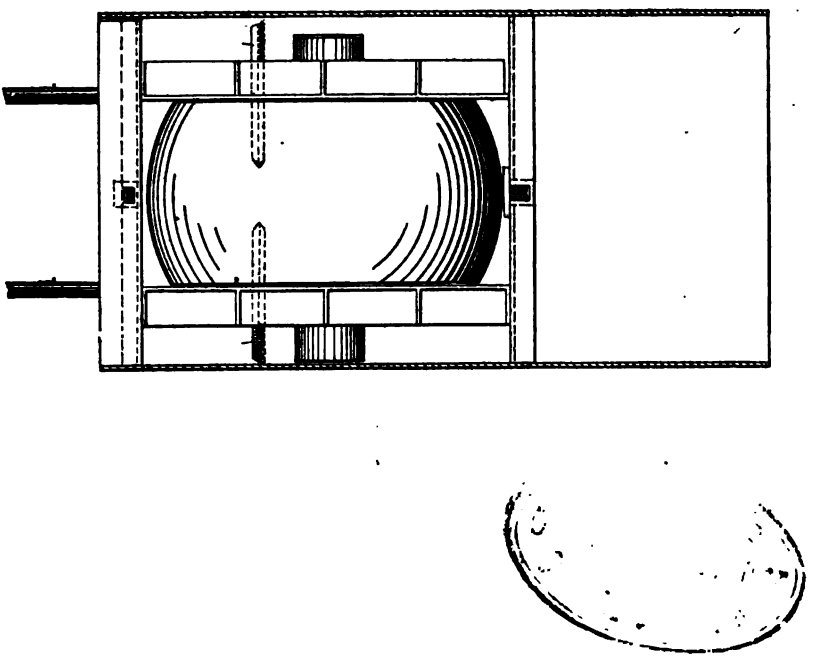
Plate 21.





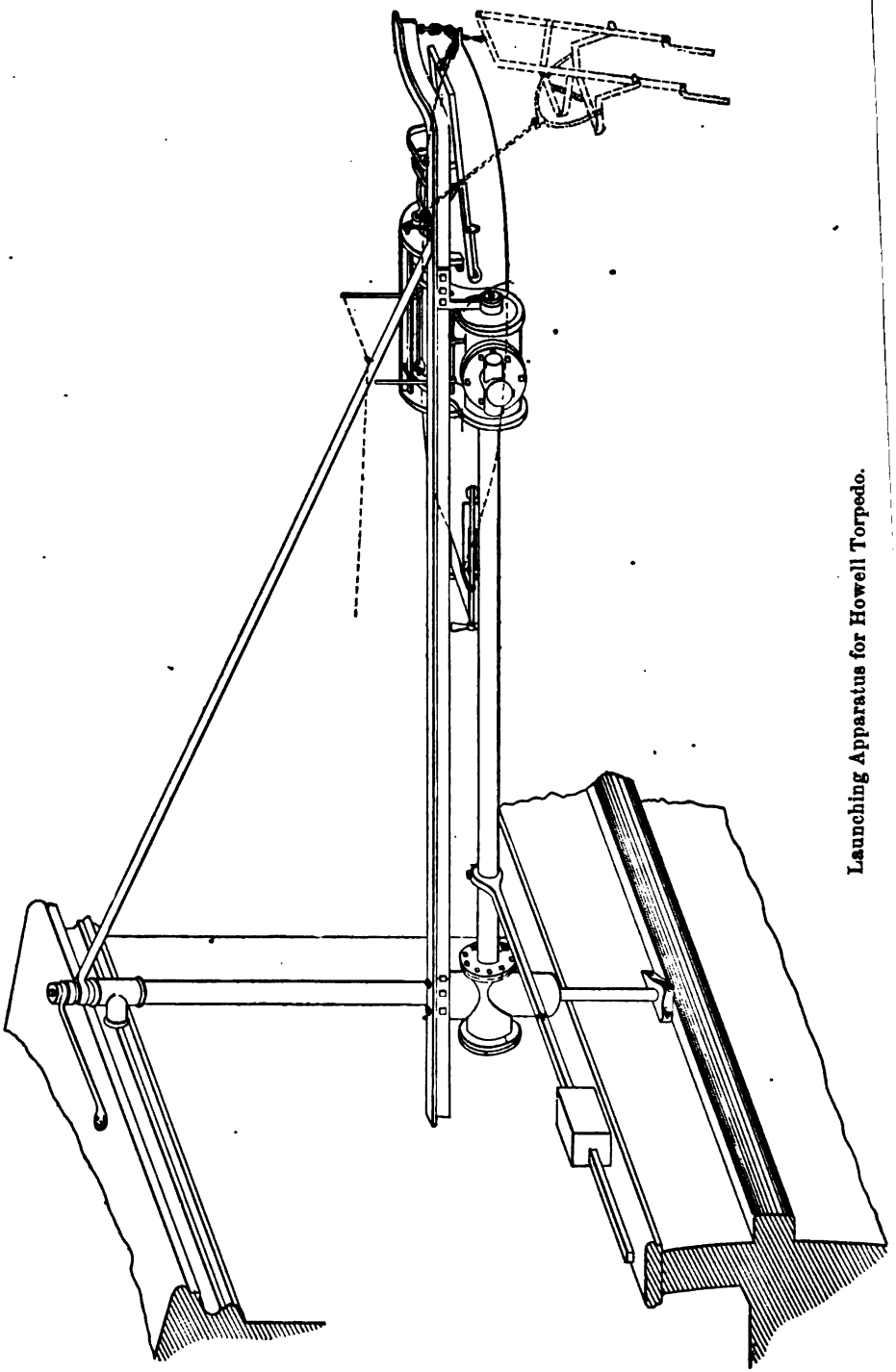
Howell Torpedo.

Plate 22.

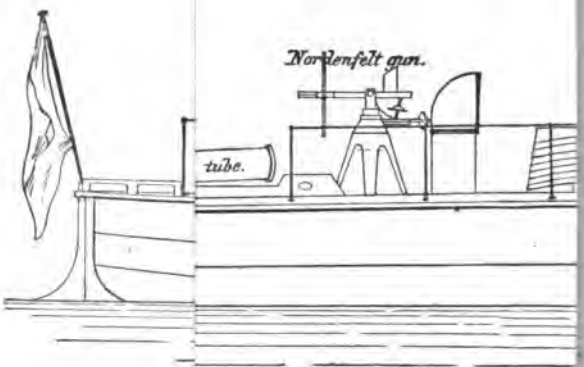


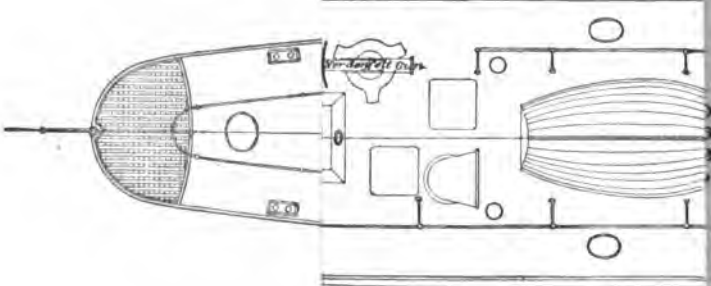
Howell Torpedo.—Fly-wheel and Shaft Gearing.

Plate 23.



Launching Apparatus for Howell Torpedo.





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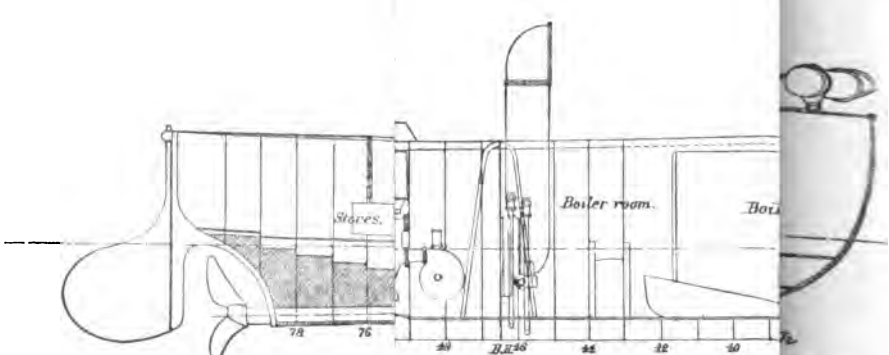


A FIRST-CLASS SEA-GOING TO

Face p. 163

A careful inspection of these extracts from the report of the Torpedo Board lead us to conclude that of the torpedoes presented the Howell is the only one that appears to justify at the present time an expenditure for purchase and experiment.

It has accuracy, fair range, moderate velocity, and certainty of operation; it is subaqueous and consequently reasonably sure of destructive power; is measurably safe, simple, and can be easily handled; while at the same time it is inexpensive and not difficult to manufacture.

Plate 21 shows top and side views, Plate 22 the fly-wheel (motive power) and shaft gearing, and Plate 23 the launching apparatus of the Howell torpedo.

Of the necessity of boats fitted with torpedoes or submarine projectiles there is no longer any doubt. All of the modern armed powers are supplying themselves with torpedo-boats of some type as rapidly as purchase or their workshops can provide. Germany alone, even with a limited coast line, considers that one hundred and fifty torpedo-boats will be necessary to properly defend her coasts.

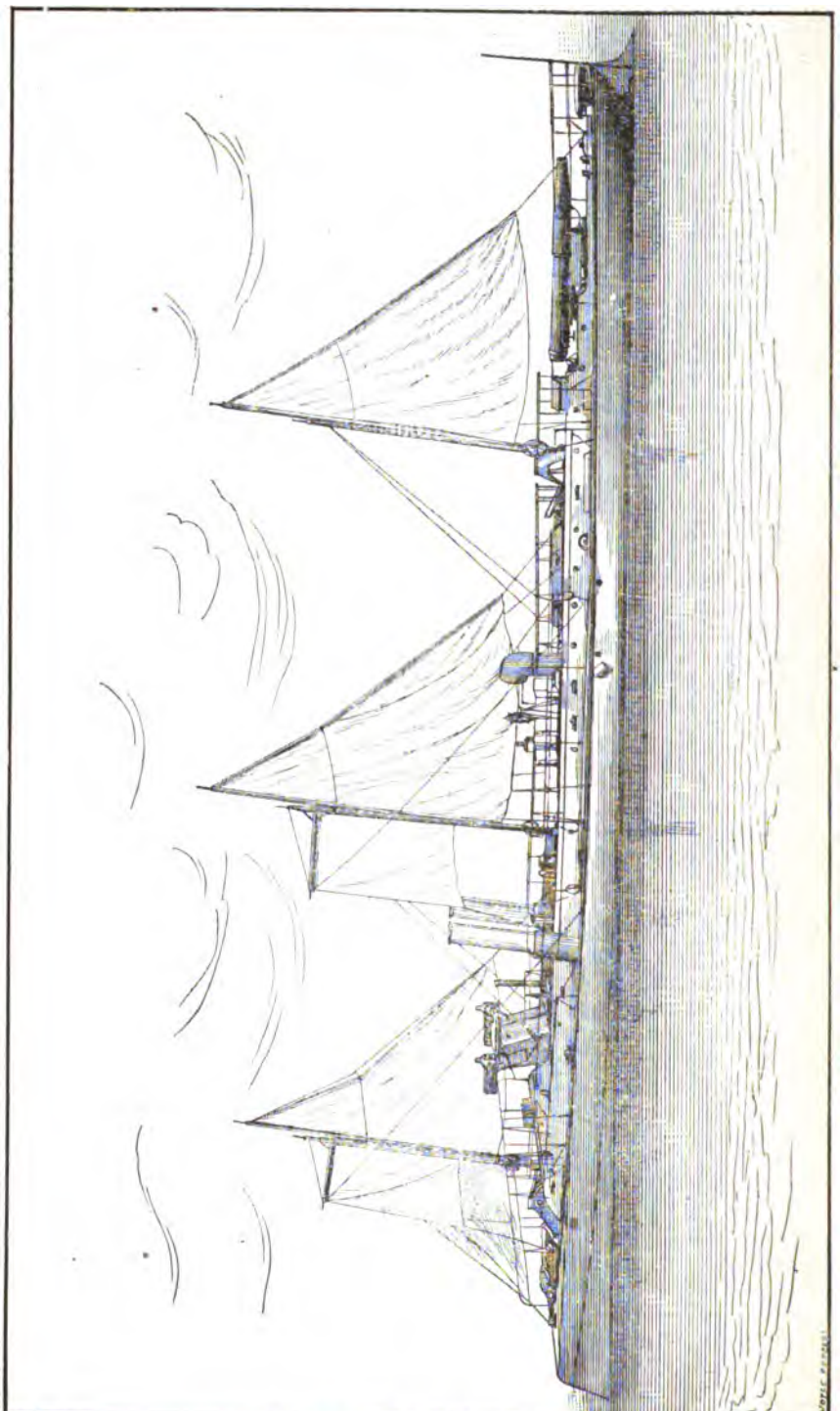
The development in torpedo-boats has been phenomenal, the last year alone showing an advance from a length of 120 feet and a speed of 19 knots, which were considered remarkable qualities in a first-class boat, to a length of 140 feet and a speed of 23 knots loaded (carrying 15 tons) and 25 knots light, together with the introduction of novel features of importance.

Plate 24 presents some of the details of an English type of sea-going torpedo-boats. Length on water-line, 127 feet 6 inches; beam, 12 feet 6 inches; maximum draught, 6 feet 2 inches; boiler pressure, 130 pounds; revolutions per minute, 425; indicated horse-power, 657; probable speed, 20 knots; bunker capacity, 19½ tons. With this quantity of coal the boat can steam 370 knots at full speed and about 2,400 knots at a 10-knot speed. The armament will be five Whitehead pattern torpedoes arranged for gunpowder impulse fired by electricity, one being in a fixed tube in the bow, two in training tubes fitted round the forward turret, and two in the tubes round the after turret. One, or all of the torpedoes, can be fired from either turret. Each turret is fitted with a John Donaldson steam steering-engine, and there is a hand-wheel on deck. Thornycroft's patent rudders give remarkable maneuvering powers.

In the second-class boats, 64 feet long, 8 feet beam, and 3 feet 6½ inches maximum draught, a speed of nearly 16 knots is obtained with an indicated horse-power of 170 with 131 pounds boiler pressure and 631 revolutions. Two Whitehead pattern torpedoes, in two fixed tubes in the bow, arranged for gunpowder impulse and fired by electricity, constitute the armament. Two rudders make their boats very handy, and are so arranged that either can be unshipped and hauled on board in case of necessity. This type is adapted for the ordinary service of a man-of-war, the stern-sheets being open. It is constructed on a life-boat principle, and readily frees itself of any shipped water.

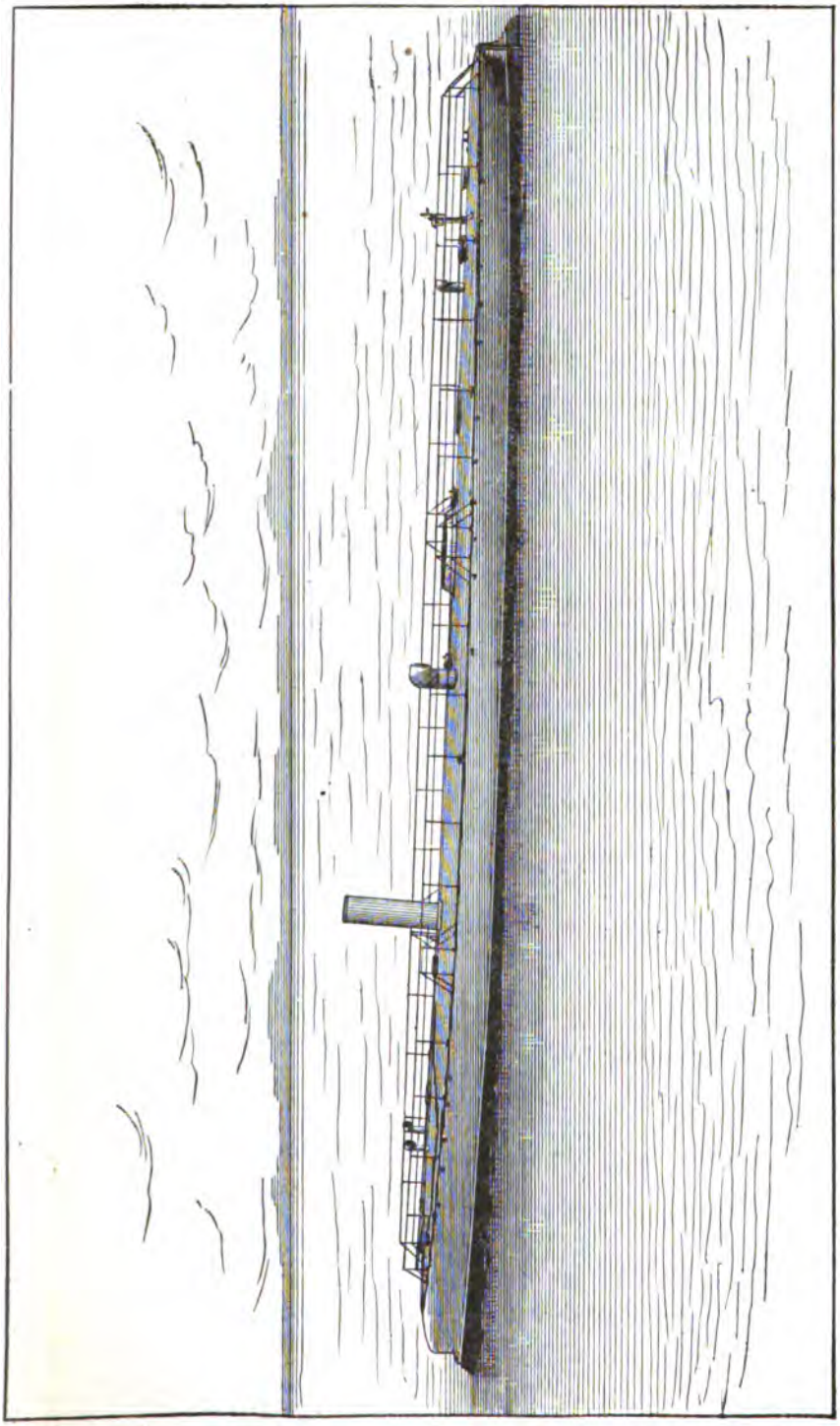
Although Messrs. Yarrow and Thornycroft have brought the second-class boats to a very high standard in Europe, I believe they will soon be abandoned there even for sea-going ships (very few are now laid down), and that the great development will be in overcoming the disadvantages of delicacy and weakness by increasing their size, giving them greater maneuvering power and safety by the introduction of two engines and twin screws, and steel-plate and coal protection against rapid-firing ammunition.

Plate 25.



English First-class Sea-going Torpedo-Boat, 1885. (Thornycroft.)

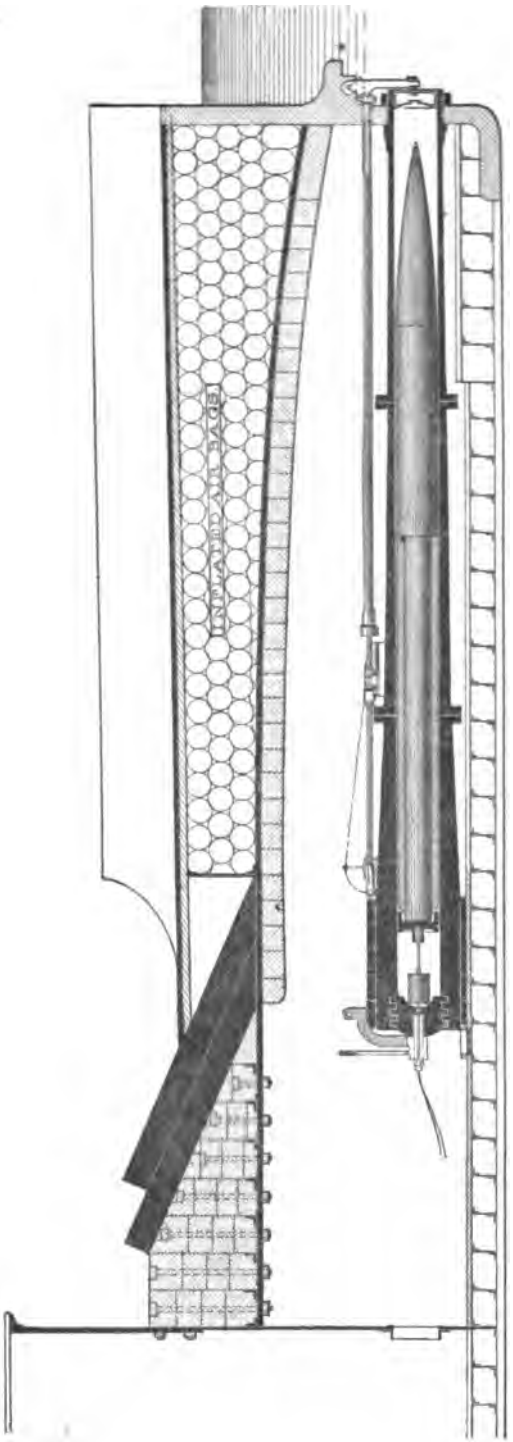
Plate 26.



Length, 125 feet. Beam, 13 feet. Speed, 19 knots. Ordered April 27, 1885. Official trial, August 13, 1885.

First-class Torpedo-Boat, English Type. (Yarrow.)

Plate 27.



Longitudinal Section of the Bow of an Iron Vessel of the "Destroyer" System.

Yarrow & Co. have already laid down some boats of this character that give promise of developing a speed of from 23 to 25 knots.

With the plants and experience possessed by Thornycroft and Yarrow, and a capacity in each of these works to finish one boat a week, England ought not to be long in overtaking her rivals.

Plate 25 represents an English first-class boat (Thornycroft pattern) fitted for sea. Plate 26 shows the recent type decided upon by the British Government, in which powder impulse will be employed for torpedo-discharge. The turrets and some other fittings are not shown in the cut.

In weighing the criticisms concerning the overestimation of the importance and usefulness of these swift skeleton boats, it must not be forgotton that most nations are sadly deficient in the education of crews for them, and that such education should be begun at the same time as the inauguration of our topedo-boat fleets.

Since the boats must carry torpedoes, a type or types must be determined upon. Lieutenant-Commander Bradford, U. S. N., in his history of torpedo warfare, has presented a valuable outline of the subject from the idea conceived by David Bushnell, of Connecticut, in the year 1771—to destroy a ship with the gas liberated by the ignition of gunpowder under her—to the development of the Whitehead in 1882; and Lieutenant-Commander Barber, U. S. N., has contributed a short but interesting history of submarine artillery.

Captain Ericsson has deemed it necessary to state that the Destroyer is not, as has been generally supposed, a torpedo-boat, but a vessel of war (a gunboat if you choose) partially armored to attack bows on at short range. No matter, however, by what name she is designated, she belongs to that *family* of weapons so greatly needed for the defense of our extensive coast-line; and if we employ the accepted definition of a torpedo—"an engine or machine invented for the purpose of destroying ships by blowing them up"—we should class her with torpedo-boats, and accept his submarine gun and projectile, Plate 27, as types of weapons for submarine warfare well to the front in torpedo experiments.

To obtain practical and full results with the submarine gun and its projectile-torpedo, it was necessary to provide a suitable floating carriage of high speed and handiness, and with such equipment as would facilitate the most thorough experiments to demonstrate the advantages and usefulness of the system.

These elements obtain in the Destroyer.

When we consider the amount of money other nations have spent for torpedo experiments, and the fact that the inventor is prepared to guarantee the due performance of the submarine gun and projectile (as he did in the case of the Monitor), it would seem a most reasonable request to ask Congress to appropriate an amount sufficient to purchase the Destroyer and to make trials with the torpedo-boat in which Captain Ericsson's experiments have been so successfully conducted and by which his system has been so well developed.

To acquire the greatest good from an invention, we should accept it at the highest state of its development; and, since Captain Ericsson has made many of those experiments which the Government must have made itself had it been the possessor of the invention, the acquisition of the Destroyer would be advantageous and economical, particularly as the cost would be less than that of any other vessel the Government

would be likely to construct for a continuance of the development of submarine artillery.

The amounts that have been expended by the various governments for the development of the Whitehead torpedo are enormous, but they are insignificant if the governments feel a sense of security in the possession of an efficient system of torpedo defense.

England alone has spent hundreds of thousands of pounds experimenting with this torpedo and the means of carrying and discharging it. Her Majesty's ship Polyphemus has been conspicuous in absorbing the lion's share of these expenditures. In August, 1883, the London Times published the following:

The country will learn with satisfaction that the Polyphemus screw ram, which is purely an exceptional ship as regards her form, armament, machinery, ventilation, and the power of her engines in relation to displacement, is likely at the eleventh hour to prove a success. This was at one time considered very doubtful, and many breakdowns were recorded. She was brought round from Chatham at the beginning of the year, since which time she has been put through constant experiments, with the object of rectifying admitted and notorious structural weaknesses and defects in her under-water torpedo gear. Her preliminary trials at the Nore and her seaworthiness during the voyage to Portsmouth justified the admiralty in running to the additional expense of replacing her original locomotive boilers by a set of ordinary marine type. But while her success as a ram, for which she was exclusively designed, was thus shown to be certain, great apprehensions existed with respect to her torpedo arrangements. The Polyphemus is intended to carry no guns, and hence with impracticable torpedo apparatus she would be dependent in action upon her ram alone.

The mechanism for ejecting the Whitehead torpedo does not greatly differ from that adopted in the Vesuvius and Inflexible, and its defective action may be therefore referred to the increased speed of the ram, 17 knots, and the increased immersion of the tubes. One of the tubes is placed in the ram itself, which is made hollow for the purpose, and two are fitted to act on the broadside. The first failed from insufficient initial impulse to force the projectile into the water and away from the ship, while it was found impossible to project torpedoes from the broadside ports, except at very slow speeds, in consequence of the tremendous pressure which the torpedo encountered from the water from the moment it left the cover of the ship and the excessive vibration of the launching gear. * * * When the speed of the ship attained about 10 knots the projectile was often so tightly nipped by the pressure that it absolutely refused to move, and it was found impossible to move it without injury to the torpedo or danger to the ship. At other times, * * * the leverage exerted upon the tail * * * was so great as to disable the propeller. Repeated attempts were undertaken with a view of surmounting the difficulty, but without success, and at length the admiralty, on the principle that a number of heads are better than one, appointed a special committee for the purpose of considering questions relating to the projection of Whitehead torpedoes from submerged tubes.

The Polyphemus was laid down in Chatham in September, 1878. Although Commander Gallwey, R. N., in a paper read March 6, 1885, before the Royal United Service Institution, on the subject of "The Use of Torpedoes in War," paid high tribute to the Whitehead torpedo as surpassing all others in efficiency, and presented arguments in favor of the "much-abused Polyphemus," according to the London Times (May 26, 1885), she has not been until now considered "to have justified the hopes of her designers, and to have demonstrated her claims to be regarded as a vital addition to the naval defenses of the country;" or, after seven years of unlimited expenditure, she has "worked out the torpedo-discharge and boiler questions," and assisted to model other ships; for, "in the two new Polyphemuses to be laid down, besides having their offensive powers strengthened by dispensing with the torpedo discharge through the ram itself, and giving them a small gun armament," other improvements are to be introduced. They are to be both longer and broader than the existing ram, and greater habitability is to

be secured by constructing an ordinary ship above the turtle deck, which will be protected by 3-inch armor."

In torpedo warfare the greatest danger to be met is to avoid the destruction of the torpedo-boat itself, and at the same time to be sure of the successful explosion of the torpedo. Lieutenant Latour's recent experience in destroying the Chinese flagship at Foo-Chow shows what a comparatively small chance he had of escape. For some time he could not get clear of the Chinaman, and was not only subjected to a galling fire of deliberate aim, but had every reason to fear that he must be carried down with her when she sank. Fortunately for him and his crew of eleven men, his engines (or something else) were strong enough to disengage him from his enemy, and by a marvelous chance he lives to enjoy the glory he so bravely earned.

While one may reasonably expect a loss of 50 per cent. of boats and *personnel* in torpedo warfare, and while this may be an economical expenditure in comparison to the enemy's loss, a torpedo-boat commander will be in a superior position if he has a weapon that can be effectively fired at his enemy, and still have 200 or 300 feet for maneuvering.

Captain Ericsson feels confident that he has accomplished this.

In conclusion I desire to call attention to the characteristics of the Whitehead and Howell torpedoes that deserve consideration.

Although the Whitehead torpedo, as a mechanical instrument, is nearly perfect, it must be remembered that the power of compressed air is comparatively limited, that the difficulties of ejection have been but barely met, that bow discharge under water has been practically abandoned, and that the mode of propulsion may not prevent its being diverted by mechanical contrivances; but it is a commercial success and is used by almost every nation of importance—excellent reasons why the United States should possess it.

Of the three Howell torpedoes manufactured by the Navy Department, two were lost at Newport, the place of trial being unsuitable for the experiments undertaken. Of the recent trials with the third, the following extracts from the official report will show the results obtained:

The action of the torpedo as to direction in the horizontal plane.—I see no reason to modify the report of the Torpedo Board, page 158, in reference to the efficiency of the "directive force" inherent in this torpedo directing it in the same course it has when it leaves the launching apparatus.

As to speed.—Steam on motor 40 seconds gave 13.34 knots; on motor 60 seconds, 15.6 knots. The propellers are not, probably, well adapted to give high speeds; at least, before it is decided that the best speed attainable has been reached, other propellers of varying pitch and surface and of approved designs should be tried.

Diving apparatus and direction in the vertical plane.—During several trials the torpedo was seen for considerable distances, while running under the water, and in every such case it was apparently on an even keel about 4 feet (the set depth) below the surface; if it were rising or diving the angle was too small to be appreciated by the eye under the circumstances.

The torpedo tried was 8 feet 11 inches total length, 13.75 inches greatest diameter, weighed 284 pounds, had a buoyancy of 10 pounds in fresh water, carried 40 pounds of lead to represent weight of explosive charge; the same torpedo in salt water would carry 60 pounds of charge without any buoyancy. It made a speed of 15.6 knots for 200 yards and a total range of over 500 yards.

In the appended reports of Lieut. Commander F. M. Barber, U. S. N., member of the Naval Advisory Board, and Lieut. E. W. Very, of the United States Navy, now a member of the firm of Hotchkiss & Co., Paris, France, will be found valuable information and suggestions in

relation to torpedoes and torpedo-boats for coast defense, together with estimates for purchase and experiment.

I have endeavored to present in a convenient form for reference such facts and authorities as will assist your consideration of the problem of providing an efficient torpedo defense. If the work is to be commenced in a manner at all commensurate with its importance, not less than $650,000 should be made available for the purchase of, and experiments with, the most advanced types of the—

Whitehead	$125,000
Howell	125,000
Ericsson	150,000
Torpedo-boats	250,000
Total	650,000

Electrically controlled torpedoes have not been considered in this paper, beyond the report of the Torpedo Board, because of their unfitness for naval warfare, viz: Low speed, the facility with which they can be taken up, impossibility of guidance in fog or smoke, and the difficulties of control from a point in motion. Moreover they are very expensive.

I have the honor to be yours, respectfully,

W. H. JAQUES.

TORPEDO-BOAT COAST DEFENSE.

By Lieut.-Commander F. M. BARBER, U. S. N.

NAVAL ADVISORY BOARD, *October*, 1885.

The principal submarine weapons are: Fixed mines; electrically controlled locomotive torpedoes, such as the Lay, Sims, Lay-Haight, &c.; locomotive torpedoes not electrically controlled, such as the Whitehead and Howell; submarine rockets and submarine projectiles.

Since both fixed mines and electrically controlled locomotive torpedoes are more conveniently manipulated from the shore, they will not now be considered.

Of the strictly naval torpedoes, the Whitehead is the most formidable locomotive torpedo in existence. It is manufactured in Austria, and every maritime nation in Europe is in possession of it. Therefore the United States ought to have it.

The Howell torpedo is the most valuable American locomotive torpedo that has yet been invented for naval use. It has already passed beyond the experimental stage and presents many important advantages over the Whitehead. Our Government should take the necessary action to perfect it.

Submarine rockets and projectiles are still in their infancy, but each presents features which cannot be attained by any torpedo that depends upon internal machinery. Money should be appropriated for the development of such weapons.

Estimates for the inauguration of means for providing suitable weapons in the United States for torpedo coast defense.

	Object.	Amount.
1	For the purchase of ten Whitehead torpedoes, with the right to manufacture; the necessary machinery, &c., for a manufacturing plant at the torpedo station, Newport, R. I	$100,000
2	For the purchase of two first-class torpedo-boats in England	120,000
3	To manufacture, by contract, in the United States, two first-class torpedo-boats, after the English boats are received and become available for models	130,000
4	To manufacture and experiment with Howell torpedoes, both from ships and boats	100,000
5	To experiment with submarine rockets and projectiles	50,000
6	To manufacture, by contract, in the United States, two second-class torpedo-boats	50,000
	Total	550,000

REASONS FOR THE ABOVE ESTIMATES.

1. The average price of each Whitehead torpedo is about $1,000. It is estimated that ten will be required, as each of the first-class torpedo-boats purchased will need four; the remaining two are for a reserve. Whitehead sells the right to manufacture, with working drawings, &c., for about $50,000. Of course our Government could manufacture without buying the right; but apart from the injustice of doing so, it would be impolitic and uneconomical, since we would necessarily have to travel over much of the same ground of mechanical mistakes that Whitehead has. It would be better to buy the results of his experience and seek to improve the weapon (which could undoubtedly be done). The remaining $40,000 would be necessary for transportation, special tools, air-compressing machinery, and other plants.

2. The two most celebrated builders of torpedo-boats in the world

are Thornycroft and Yarrow, in England. Each is capable of producing a first-class torpedo-boat, from 100 to 130 feet long and with 10 to 14 feet beam, that will steam at the rate of from 18 to 22 knots per hour for 370 knots, or at the rate of 10 knots per hour for 3,000 knots. Each builder produces an excellent boat; but as each differs from the other in his methods of arrangement of machinery, bulkheads, braces, launching apparatus, &c., it is most desirable that our builders should have the advantage of the experience of both. The cost of these boats varies from $55,000 to $60,000 each; perhaps more if only two boats are ordered.

3. In order that we should have an independent torpedo defense, it is absolutely necessary that we should be able to manufacture torpedo-boats in this country of the most efficient types. The English torpedo-boats could be delivered here within from four to six months from date of contract. On their arrival, they should immediately be sent to Washington or Newport and the prominent builders of the country should be invited to attend a series of trials with, and to thoroughly inspect, them in all their details. After this, two boats should be contracted for from two responsible bidders, in order to find out what the builders are capable of producing and what improvements can be made on the English models. These boats should be subject to the most rigid Government inspection during their manufacture. They would cost at least $65,000 each.

4. As the Howell is at present the most promising competitor of the Whitehead, it should be brought to the utmost perfection. Its principal advantages over the Whitehead are its directive force, its size, and its cost. Its remarkable power of maintaining the direction in which it is pointed, when acted upon by a deflecting force, makes it possible to launch it with accuracy from the broadside of a vessel in rapid motion, which in my opinion is the most practical method of using a torpedo at sea; *no other torpedo* presents the advantages in this respect that are possessed by the Howell. Its size is not more than one-half that of the Whitehead, which is the most important feature in regard to handiness in use and storage on board ship. The Whitehead is from 16 to 20 feet long and from 14 to 18 inches in diameter, while the Howell, carrying the same explosive charge, is from 8 to 9 feet long and from 12 to 15 inches in diameter. Its cost is less than one-half that of the Whitehead; but as it is still an imperfect weapon, it is necessary to further develop it and also to perfect the method of launching it, both from ships and from first-class torpedo boats.

5. By submarine rockets and projectiles I do not mean the gigantic rocket of Weeks or the ponderous projectile of Ericsson, but a weapon 7 or 8 feet long and from 12 to 15 inches in diameter, which can be manipulated from second-class torpedo-boats. A weapon of this species possesses a theoretical advantage over any locomotive torpedo in the fact that there is no internal machinery to deteriorate with time or to require constant attention; and it is much simpler in its manipulation and action. The range, though limited, would be ample for harbor work. Very little in this field has ever been done either in this country or in Europe; but I think that it is well worth $50,000 to the country to investigate it.

6. A second-class torpedo-boat is from 40 to 60 feet long and with 6 or 8 feet beam. The use of these boats is gradually being abandoned in Europe except for use from sea-going ships; but in Europe the harbors are very small, and it has been found that practically every torpedo-boat for coast defense must be able to go to sea. The tendency is, therefore, to confinement to the first-class boats. A second-class boat

is, however, much handier and cheaper than a large one, and in this country, where we have such large bays as the Chesapeake and Delaware and harbors like New York and San Francisco, the second-class boats would be found exceedingly convenient and abundantly large for sheltered waters. It is from these boats that I would propose to use the submarine rockets and projectiles, or, if desirable, the spar torpedo.

The spar torpedo has been perfected at Newport, but we want something better; something that can be thrown at the enemy when he is beyond the reach of a club. The Whitehead and Howell torpedoes, when dropped into the water from even a very moderate height, will descend to a distance of 18 feet. There will be many cases when it will be necessary to use a torpedo in less than 18 feet of water, and my idea is that some species of rocket or projectile is desirable to be fired from a second-class torpedo-boat in the line of the keel or otherwise, when a range of from 50 to 100 feet would be ample, and when a first-class torpedo-boat might be unhandy to manipulate. Herreshoff will build a wooden 40-foot spar torpedo boat that will make 19 miles an hour for from $12,000 to $14,000; but a 60-foot boat, of steel, well built and equipped, will cost $25,000.

For a proper torpedo-boat defense of the coast of the United States, including the Great Lakes and Alaska, for a threatened war, there would be required *two hundred* first-class and *sixty* second-class torpedo-boats.

Roughly estimating, there would be one first-class torpedo-boat for every 60 miles of coast, and they would be within three hours' steaming distance of each other. There would be three second-class torpedo-boats in each of twenty important harbors and bays. The first-class torpedo-boats are capable of concentration anywhere along the coast; the second-class boats remain always in the harbors to which they are assigned.

This fleet would cost $14,000,000, and would require 520 officers and 3,280 men, with a reserve of 130 officers and 800 men.

The exact division of this fleet would depend upon the relative importance of the cities and harbors along the coast, but generally speaking, it would be divided into twenty groups, each group having a patrol of 600 miles of coast, which would be an easy steaming distance for any of the ten first-class boats in the group. In time of actual war, the number of boats would have to be increased according to the naval power of our enemy, for it must be borne in mind that there would be a very heavy percentage of loss of these boats not only from the machine-gun fire of the attacking force, but also from the enemy's torpedo-boats, which either England or France could and would transport to this country in great numbers in two weeks' time from the declaration of war. The popular idea in this country that tugs, yachts, and open launches could in an emergency be fitted with spar torpedoes and perform successful work in the coast defense is a wrong one. Twenty years ago it was true, but not now. It should be distinctly understood that in the matter of naval torpedo defense we are at this moment behind every European maritime nation.

If our war was to be with England the number of torpedo-boats would probably be required to be doubled on the Atlantic and quadrupled on the Pacific coast and Great Lakes. If with France, the number would be doubled on the Atlantic and Pacific coasts and trebled in the Gulf. If with Spain, the number would require no increase. If with Chili, the number on the Pacific coast should be quadrupled, by shipping from the east by rail.

After settling upon the best types of torpedoes, it would seem that the best method to pursue to put the United States in a properly defensive position would be to make an annual appropriation for the building and equipment of twenty torpedo boats per year till the requisite number is acquired, and to commence building at once. In Europe where the Whitehead finds few or no competitors, the boats are all made for either the Whitehead or the spar, or both; but in the United States it is claimed that other torpedoes can be made which will be superior to the Whitehead (although the latter is known here only by reputation).

Since this is the case, and since the general features of the boat depend upon the torpedo to be used from it, what is needed at present is an appropriation such as I have indicated, whereby the United States will come into possession of the Whitehead and at the same time will develop what appear to be the most promising ideas in this country. One or two years' practical liberal experimental work, which, in my opinion, this $550,000 would allow, would so far determine the most useful torpedoes that we could then begin to build an annual supply of boats, torpedoes, &c.

If the amount I have named should be deemed extravagant, then I should recommend an appropriation of $260,000 to be expended as follows: $100,000 for the purchase of the Whitehead, as before described; $60,000 for the purchase of one first-class English torpedo-boat; $50,000 for the purchase and development of the Howell torpedo; $50,000 for the development of submarine rockets and projectiles.

If only $150,000 can be made available, then expend $100,000 for the Whitehead and $50,000 for the Howell.

If only $50,000 can be made available, then expend it *all* for the purchase and development of the Howell.

REPORT ON TORPEDO BOATS FOR COAST DEFENSE.

By Lieut. E. W. Very, U. S. N.

PARIS, FRANCE, *August* 26, 1884.

Of all the special branches of naval equipment, none is at present receiving a more careful and wide-spread attention amongst the European naval powers than that of the torpedo boat for coast defense. Every country, without exception, that possesses a sea-coast is at this moment engaged in building, or having built, boats suitable for this service. Portugal alone, of all these countries, possesses less than nine boats competent to take part in coast defense. (In the use of the word *coast*, its literal definition is intended.) Every evolutionary squadron has its attachment of torpedo boats forming an independent flotilla, fully able to accompany the squadrons under all circumstances of wind and sea. In all countries officers are picked from the lower grades of the executive corps, and are given a special training in handling them, to acquire an intimate knowledge of every detail of the boats and of their native coasts. The crews form a picked corps of men thoroughly instructed in the working of the machinery and weapons, and with but one or two exceptions each nation builds its own boats.

The unanimity with which foreign naval powers are developing torpedo warfare seems to prove that decided recommendations should be made with regard to torpedo boats.

In making a report upon torpedo boats for coast defense it seems best

to start from the basis of the recommendations of a board of German naval officers, made in March last to the Reichstag. It must be borne in mind, 1st, that in 1873 a German advisory board laid down a complete programme for the reconstruction of the navy; 2d, that as this programme has been filled, it has been accompanied by constant practical tests which have led to many modifications of detail, although the main summary has never been deviated from; 3d, that no deviation has ever taken place upon theoretical considerations alone, but only after direct experiment has clearly proved that a strict adhesion to the original projects was erroneous. The following extracts from the report above referred to contain all that is pertinent to the subject under consideration:

The development of submarine mines and of locomotive torpedoes has at present reached such a point that we do not expect important advances to be made in either system during the coming year, and, such being the case, we are of the opinion that we should now acquire the best material existing for both systems. For many years we have patiently allowed other navies to take precedence of ours in this development, in order that when the proper time should come to fully equip this branch of the service we might be absolutely certain of advancing in the true direction. That time has now come, and we must cease observation and proceed at once to the complete defense of the German coast. * * * The idea which was formerly cultivated, and which was expressed in the original programme of fleet development, of having special torpedo vessels of a medium size, has not been realized, and is not recommended on account of the many obstacles presented by the attempt to satisfactorily combine speed, armor, maneuvering power, torpedo and gun power. * * * The design of providing each ironclad with two torpedo-boats has as yet not been fully carried out, as it is considered better, if possible, to make these boats larger and more seaworthy, in order that they may accompany an iron-clad squadron as an independent attachment.

For fighting along the home coast these boats will be able not only to accompany the ironclads but to engage in independent coast operations. For foreign expeditions, too distant to make them independently applicable, they may be transported to the scene of action on special transport ships.

Torpedoes, as well as torpedo-boats, are now manufactured exclusively in native German establishments. * * * These boats are about 98 feet in length, with very light draught, carry a complement of one officer and about fourteen men, two torpedo dischargers, and, as a rule, two revolving cannon. They have no rig whatever, but carry coal enough to drive them 1,000 miles, at a speed of 10 knots. The few boats of this class which the German Government has possessed up to this time (eleven in all) have been well taken care of. * * * The small size and very high speed of these boats make them very difficult targets to hit, so that in this respect they possess a great advantage over heavy ironclads. * * * It must be remembered, however, that it is not probable that the success of an operation would be made dependent upon a single shot or a single boat, but that attacks would be made by from two to six boats, attacking from different directions. It is possible, therefore, at the risk of a loss of a minimum number of men and of a few cheap and quickly-built boats, to sink a colossal war-ship in a single attack. Even in bright moonlight, and with the greatest possible care and alertness, it becomes impossible for a ship to anchor for a single night on a coast well defended by these torpedo-boats.

Numerous and well-provided torpedo-boats make a blockade an undertaking of the most difficult character. It makes it necessary for the blockading squadron to haul off the coast every night. Its coal supply is thereby wasted, the harbor is left open at night, and the actuality of the blockade is threatened. Even though under way the squadron is not safe, for the boats can follow it out and find the ships.

It is readily conceivable that in an energetic defense of this kind many boats will be disabled through accident and the enemy's fire, and therefore the total number of boats must not be limited to that barely necessary for the active work. * * * In considering this matter it is not a question of any single modification of type, or of single vessels, as would be the case with vessels of the fleet, but it is a necessity that the German torpedo flotilla should be brought up to the number of 150 boats, for coast defense, the armament of war ships, and a reserve for replacing disabled boats.

With this number the German fleet will stand first in the world in respect of torpedo defense, as is shown by the following table of torpedo-boats possessed by different nations:

England has built 22 first-class and 97 second-class, and is building 4 first-class and 6 second-class—total, 129.

France has built 13 first-class and 53 second-class, and is building 3 first-class and 7 second-class—total, 76.

Russia has built 4 first-class and 117 second-class, and is building 4 first-class—total, 125.

Italy has built 18 first-class and 21 second-class, and is building 14—total, 53.

Holland has 24, Norway and Sweden 15, Austria 14, and Denmark 9. England, France, and Austria contemplate an increase in the immediate future.

The average cost of a torpedo boat, with its torpedoes and revolving cannon, amounts to 240,000 marks ($57,170). In order to attain this number of boats it is necessary to provide for building 115 new ones.

The opening statement and the final recommendation of this report leave no doubt whatever with regard to the opinion of German naval officers that the torpedo-boat has passed entirely beyond the experimental stage, and has entered as a permanent element into the constitution of the fleet. As they say, there is no question here of types of vessels or of single ships, but the flotilla must at once be brought up to its full standard. Coming as these statements do, from a people so methodical and certain in all matters of military improvement, it would seem that an acquisition of these boats by the United States is of the *first* importance, and that action should be taken at once.

In entering into an argument with regard to the importance of this type of naval defense for our own coasts, it is necessary to have as complete an understanding as possible of the boat itself and its development. The appendix to this report contains important data, illustrating the improvements and present condition of the boats.

From these data it will be seen that the fully developed first-class torpedo-boat of to-day is in general terms a craft about 100 feet long, with a draught of from 4½ to 6 feet of water; a capability of maintaining a speed at sea of not less than 16½ knots; an endurance at this speed of over 150 miles, and a maximum endurance of from 650 to 1,200 miles; an armament of torpedoes and revolving cannon, and a capability of keeping the sea under all conditions of weather.

In examining the especial work of this type of boat, attention is drawn to the custom now almost universal in Europe of considering the total work of the coast defense as divided into three distinct sections, called lines of defense.

The inner line consists of the coast fortifications and other channel defenses, such as mines and permanent obstructions. Indefinite extension of fortifications, such as would render the coast difficult of access, is impracticable. The great expense of construction and maintenance limits their position to those points which are of the most vital importance to the safety of our seaboard towns. Even at these points the best armed fortifications are considered insufficient of themselves to effectually check an active enemy from doing almost irreparable damage to the places which they are designed to protect. In order to enable them to develop their full power a defense must be organized in the approaches themselves. In the cases of approaches that possess little commercial but great strategical value, these supplementary defenses may consist of permanent obstructions, blocking the channels completely and needing only such protection as shall insure against their removal by an enemy. In approaches of great commercial value, this system cannot be applied except at a period of the most dire necessity. The channels must then be defended by mines. These mines, however, must not be of such a nature as to hamper the free movements of friendly commerce or naval vessels except when the enemy is actually present, and the matter of opening or closing

channels at will is one of the most difficult things to accomplish, particularly with an active enemy in the vicinity, who, by skillful countermining, may in a single night make a havoc in these defenses that it will require days and perhaps weeks to remedy, requiring resort to permanent obstructions.

In order that these important approaches may be kept open until the last moment, that time may be gained by giving warning and possibly holding an enemy in check until they may be made secure and to prevent their removal or disabling when in place, a second line of defense is rendered necessary. As it is this line which depends for its main strength and effectiveness upon torpedo-boats, I will pass to the consideration of the outer line first.

The outer line of defense consists of the sea-going fighting vessels proper, both armored and unarmored. If an armored force appears before any important point on the coast, it must be met by a force of at least equal strength and driven off, otherwise a blockade is established. It must be borne in mind at this point that, if a channel is blocked by our own mines or obstructions, the object of a blockade is fully attained, so that an enemy is really relieved of the necessity of keeping a strong blockading force in the vicinity; and in points where his strong force is present, these mines and obstructions are a most powerful aid to that force. There are many methods of modifying this drawback, but none can neutralize it except in a very partial manner without the assistance of the middle line of defense. An enemy's force acting in squadron requires a massing of the vessels of the outer line into squadrons to act against it. An active enemy using vessels singly requires the most constant movement of the individual vessels of the outer line to keep him off. In these cases a single vessel may keep several constantly confined to one portion or stretch of coast to guard it. Thus the outer line is rendered liable at any time to be called off from even the defense of a most important point, to meet and check or drive off a concentrated movement at some other point.

Coming now to the second or middle line of defense, we find its duties to be: To inaugurate a living defense of the approaches, that can distinguish friend from foe; that shall by its mobility and strength effectually bar the way to the sudden incursions of single vessels of the enemy, thus permitting commerce to freely pass in and out up to the last moment; that shall assist the fortification to guard the mines from counter-mining; that shall leave the ships of the outer line the greatest freedom possible in movement, so that their sudden withdrawal at a call or in chase shall not leave a point open to attack; that shall finally render a blockade by the enemy a hazardous undertaking, forcing him to haul off the coast at night; and that shall prevent him from taking up a position for bombardment out of reach of the fortifications and mines, and, in case of *mêlée* on the coast between squadrons, that can advance and take part.

To keep the approaches constantly barred to the enemy and open to friends is the specific duty of the coast defense. It is of the same nature the world over, being unaffected in this respect by either the political or geographical situation of the country. In the United States, however, the *importance* of this part of a war programme is superior to that of all others, since in a war with any country except England or Mexico, the first attack on national territory must be on the coast, and with England the danger to the coast is greater than that to the Northern border. Naturally, then, in developing a defensive power, the coast defense should receive the first attention.

Examining the present condition of our coast defenses, it will be found that the inner line is the best provided. Whatever may be the deficiencies of the fortresses, the channel protections can quickly be made available. Technical knowledge is here of far more vital importance than actual material, and, thanks to the schools of Newport and Willets Point, the United States is in a position to hold its own with the world, so that in case of an outbreak this part of the defense could be quickly and effectually put in operation, and thus be of great service in allowing time for the full development of the other lines.

As has been shown, however, this channel protection is open to destruction by an active enemy, and requires a vigilant guard, just as much as an army requires outposts.

Attention is here called to an invention now regarded with great favor, which has been introduced in Germany, France, and Austria, and for the purchase of which Italy is negotiating. It is a system of mines (the invention of an Austrian naval officer), that may be laid down by a vessel running at slow speed in such a manner as to effectually close an approach. The system may be taken up almost as quickly as it is laid down, and in this manner approaches may be left free until the danger is actually in sight.

Passing to the outer line of defense, it is found to be lamentably weak, although it exists to a certain degree and gives evidence of development. This line is, however, one that cannot be quickly established. Years are required to build a single ironclad, and it is almost beyond possibility to arrive at the construction of more than one at a time during peace. With regard to the unarmored vessels, we have yet to test the amount of their value (which seems to be very great) in this line as it will probably be several years before enough of them will be afloat to make any effective combination whatever.

The second line of defense in all navies consists of torpedo-boats, with what are known as floating gun-carriages and torpedo gunboats as supporters. This line with us has, in point of fact, no existence whatever, although the weakness of the first line, the time required in war to strengthen that line, the innate power of the second or middle line itself, and the necessity of its existence as a guard over the inner line, all imperatively demand its development. Without the existence of an outer line the middle and inner ones can keep the enemy off, break a blockade, and frustrate operations. With the partial development of a middle line, concentrations can readily be made that will enable the inner line to be developed with the greatest speed. Without the middle line our outer line is utterly powerless to spread its support, and the inner one is in constant danger.

In scanning the coast defense development all over Europe it will be found that, whilst the fortresses are incomparably stronger than our own, their strengthening has been of a very gradual nature, and, as artillery improves, the rearmament of the coast forts is the last strengthening carried out.

The channel defenses, being a matter mainly of technical education, cannot be measured in its development, and in so far as the education is concerned we are not behindhand. In the outer line, our attention has been constantly turned to the construction of the great iron clads. The fleets are large, and immense expenditures are made to increase their number.

Considering the second or middle line, we find nearly every navy in the world with a full schedule of floating gun-carriages and torpedo-

gunboats, the result of a constant growth since 1869. With the torpedo-boats, however, the development becomes at once strikingly marked. In 1873 there was one builder in the world (Thornycroft). In 1883 we count as builders exclusively devoted to this work two in England, two in France, three in Italy, three in Germany, two in Russia, and one in Austria. To induce such a rapid increase there must be a powerful support. Within the past *year* we find Government orders given for not less than 90 first-class torpedo-boats of over 90 feet length. Finally, we find the youngest and most enterprising naval establishment of the world (Germany) devoting almost one-fourth of its entire naval appropriation ($4,000,000) to the immediate construction and equipment of 70 torpedo-boats, with an additional demand for 45 more to be constructed as soon as these are finished.

It is evident, therefore, that in our naval development the coast defense is of vital importance, and that the middle or torpedo-boat line requires the very first attention.

In determining the amount of material and its cost necessary for an efficient constitution of this second or middle line, it seems best to first make an estimate of the war strength absolutely requisite. Having this and knowing the time required to build and fit out a single element, the requisite peace strength may be deduced which is necessary for creating sufficient technical and practical skill for war emergencies, and for distributing a proper degree of building skill which will make it possible to quickly raise the strength from a peace to a war footing.

The first step in this investigation is evidently the most difficult one, as, aside from the fact that ideas differ widely as to what the United States should consider a war strength in any detail, positive experience is lacking as to the exact strength of the individual torpedo-boat as measured by its capability of keeping the vessels of an enemy at a distance.

In making an estimate the following limitations have been observed:

1st. Weight has been given to the probable support of gunboats, vessels of the outer line, and steam-launches in support of the torpedo-boats during their different services.

2d. Only the defense of the most important commercial centers, naval depots, and entrances to water-routes are allowed for, and the torpedo-boats are supposed to be collected in divisions at these points to perform work in the immediate vicinity. Such would certainly be the first disposition on the outbreak of war.

3d. The divisions are supposed to be able, at need, to furnish a certain amount of mutual assistance and re-enforcement within certain limits, these limits being the boundaries of coast defense districts, and the divisions thus furnishing mutual support forming independent flotillas.

4th. Three boats are considered as forming the smallest division that can do effective work under the majority of circumstances.

5th. The mean size of these boats is considered to be represented by the French and German 98-foot boats, which are the smallest ones thoroughly capable of acting independently in all weathers and positions. In estimating the complements required for these boats, one officer is allowed to each, a full crew of fourteen men to each active boat, and half crews to each reserve one.

The reasons governing the assignment of certain numbers of boats to each division have been carefully considered, and each number has been fixed only after a careful consideration of the circumstances connected with the defense of each place. The summary is as follows:

Estimate of minimum war strength in torpedo-boats required for the coast defense of the United States.

Districts.	Divisions.	Boats.		Officers.	Men.
		Active.	Reserve.		
1st.—Gulf of Maine....	Portland	3	1	4	49
	Boston	4	4	8	84
	Cape Cod Canal	3	1	4	49
	Flotilla strength	10	6	16	182
2d.—Long Island	Buzzard's Bay	4	1	5	63
	Narragansett Bay	4	4	5	84
	Long Island Sound	4	1	5	63
	New York Bay	8	4	12	140
	Flotilla strength	20	10	30	350
3d.—The Bay.....	Delaware Bay	8	4	12	140
	Chesapeake Bay	8	4	12	140
	Flotilla strength	16	8	24	280
4th.—The Carolina	Wilmington	3	1	4	49
	Charleston	3	1	4	49
	Savannah	3	1	4	49
	Flotilla strength	9	3	12	147
5th.—The Gulf	Florida Keys	8	4	12	140
	Pensacola	3	1	4	49
	Mouths of Mississippi	6	2	8	98
	Galveston	3	1	4	49
	Flotilla strength	20	8	28	336
6th.—California.....	San Francisco Bay	4	4	8	84
7th.—Northwest.....	Columbia River	3	1	4	49
	Puget Sound	8	4	12	140
	Flotilla strength	11	5	16	189

Accepting 90 torpedo-boats as the minimum number to provide effective means of defense in time of war, to what extent may this number be economically reduced and still render it possible to attain the full strength in time to prevent an enemy from profiting by the reduction?

In the first place, all wars that have occurred, during the past fifty years certainly, have practically proved that naval hostilities produce decisive results in less than three months from the outbreak of hostilities. Secondly, in order that boats should be built with adequate rapidity, a knowledge of the special building requirements is absolutely necessary, and this knowledge scarcely exists with our mercantile builders at present. Thirdly, the effective management of these boats, and the peculiar nature of the service, make of it an important specialty of the naval officer's profession. This special knowledge can only be obtained by extended practice, and falls entirely outside of the capabilities of those who have not received a thorough practical training. In the case of a war, when the *personnel* of the Navy would be suddenly increased, neither the volunteer fireman, machinist, nor officer would be fitted. The *personnel* of this branch must be made up of picked men, thoroughly trained. Lastly, to superintend the very rapid building of these boats officers and men must be detailed to watch and superintend the construction, that they may be familiar with every detail.

To determine a peace strength that will furnish the necessary instruction to builders and *personnel*, the reserve may be struck out without

disabling the force, and the points to be defended may be divided into two categories according to the degree of importance and probability of attack within the time allowed for strengthening the entire flotilla. By withdrawing the defense of the points of the second category, leaving them to the defense of the inner line, with a chance of aid from the boats retained in the first category, the following reductions may be made:

Flotilla strength.	Division.	No. of boats.
First district	Boston	4
Second district	Narragansett and New York	12
Third district	Delaware and Chesapeake (one-half)	8
Fourth district	Charleston	2
Fifth district	Mississippi	3
Sixth district	San Francisco	4
Total		34

This estimate gives a peace strength equal to less than one-fourth of the war strength, and this strength properly handled could, without doubt, make itself of inestimable value in keeping an enemy at a respectful distance during the first months of preparation.

Thirty-four boats being considered the least number proper for a peace establishment, the highest interests would seem to be served in providing them at once, as is the case with Germany. But our builders (having had no experience in this work) could not meet such a demand, and it would be very difficult to secure a sufficient appropriation for the object. A sufficient number, however, should be purchased from European manufacturers to serve as models and to provide a sufficiently large flotilla with which to commence the training of officers and men.

In this way not only is a boat of the most improved pattern in every respect secured, but, what is of more value, working drawings will be secured which would be of the greatest aid to builders. Again, provision must be made in arranging for building ourselves, to as far as possible gain the power for each coast district to provide its own boats. The immense extent of the coast and amount and variety of the work to be done in establishing a thorough defense makes this all-important.

Very respectfully,

EDWARD W. VERY,
Lieutenant, United States Navy.

Hon. WM. E. CHANDLER,
Secretary of the Navy.

APPENDIX.

The table at the commencement of the following description is arranged for the purpose of giving a preliminary idea of the general steps followed in the development of the size, speed, endurance, and power of torpedo-boats. Five examples are chosen as type models, as follows:

1st. Boat No. 1, the first special fast torpedo-boat ever built, designed and constructed by Thornycroft for the Norwegians.

2d. The Lightning, the first boat ever built for harbor and coast work of an independent nature. Designed and constructed by Thornycroft for the English.

3d. The normal second-class boat as now built, to form a part of the torpedo armament of ironclads, and heavy, unarmored cruisers.

4th. The Batum, the first cruising torpedo boat ever built. Designed and constructed by Yarrow for the Russians.

5th. The Suchum, the largest cruising torpedo boat as yet built, and considered to represent the maximum size to which the unarmored boat will be carried. Designed and constructed by Thornycroft for the Russians.

Development of the torpedo-boat.

Name.	Date of building.	Length.	Beam.	Draught.	Displacement.	Maximum speed.	Horse-power.
		Feet.	*Feet.*	*Feet.*	*Tons.*	*Knots.*	
Boat No. 1	1873	57	7½	3 mean	5	14.94	90
Lightning	1876	84½	10½	5 mean	25	19.4	350
Normal second class	1881	63	7½	3 7/12 aft	10½	17½	150
Batum	1880	100	12½	4 aft	48	22.16	500
Suchum	1883	113	12½	6 aft	50½	19.49	750

Name.	Steam pressure per square inch.	Revolutions.	Coal supply.	Endurance at 10 knots.	Armament.
	Pounds.		*Tons.*	*Knots.*	
Boat No. 1	85	453	1	80	1 towing torpedo.
Lightning	110	500	5	.....	3 Whitehead torpedoes.
Normal second class	118	554	1½	.....	2 Whitehead torpedoes.
Batum	130	392	5	450	4 Whitehead torpedoes.
Suchum	130	415	10	1,000	4 Whitehead torpedoes. 1 Hotchkiss 37-millimeter gun.

The Norwegian boat differed radically in every respect from any other fighting boat that had ever been previously built, thus furnishing a distinct type. Her peculiarities may be summarized as follows: Steel frames and plating; great length in proportion to beam; no sheer at all; extremely fine lines; division into six water-tight compartments; complete deck covering; compound engines with independent pumps and surface condenser; forced draft under the grate-bars; and the screw abaft the rudder. Her armament was a towing torpedo somewhat similar to the Harvey, which, it will be remembered, was the most popular of the naval torpedoes in 1872–'75.

In so far as the general model of the boat is concerned no alteration has taken place of any note since that time. Up to about 1880 all boats had vertical stems, but since then the invariable rule has been to give them pronounced and strengthened ram-bows. This modification was introduced as a result of the bad ruptures to the bows of several boats which had collided. There has been one exception to this rule which developed a point worthy of notice. Shortly after the construction of the Batum the Danes ordered a similar boat. On her trip from London to Copenhagen it was found that the swell of the lines of the ram-bow, occurring just forward of the mouths of the torpedo tubes, carried the water up against the tube-stoppers, interfering with the boat's speed and steering power. When, the next year, the Danes ordered the Delfinen (a sister boat) they gave her a straight stem, so that the mouths of the torpedo tubes came almost abreast the stem-post. It was found that this alteration entirely cured the bad water-lift. However, since that time improvements have been made so that at present the tubes do not project beyond the skin of the boats, so that the ram-bow presents no difficulty. This point is only noted in case it should be found expedient hereafter to project the torpedo tubes.

In all the first boats the screw was abaft the rudder, and Yarrow still adheres to this disposition, although it presents serious service objections, as will be shown. About 1878 Thornycroft shifted the screw to its normal position; shortly afterwards, the lower part of the stern-frame was cut completely away, and the screw-shaft was given an inclination such as to bring the hub of the screw on a line with the keel, the lower part of the rudder being hung to an attachment on the hub itself. An interesting series of experiments was carried on by Yarrow in 1879 with regard to

the position of the screw. In that year a Herreshoff boat was sent to England to compete with the English boats, and in this boat the screw was entirely underneath, and about two-thirds aft of the midship section. Greater speed and turning power was claimed for this disposition. The Italian Government directed Yarrow to test the arrangement in a first-class boat, then being built for them. In this boat the screw was first tried in the Herreshoff position, then midway between that and the normal, and finally in the normal position. In all three cases the engines developed 480 indicated horse-power, the speeds being as follows: Herreshoff position, 18.3 knots; midway position, 19.2; normal position, 20.7 knots. Much of this difference Yarrow ascribed, and with reason, to an increase of skin friction in the first two positions caused by filling in the ordinary screw aperture and altering the after-body to allow the screw to go under the bottom. All boats are now built with the screw in the normal position, except Yarrow's, as above stated.

There have been several alterations in the rudder of minor importance, principally due to alterations in position of the screw; in regard to shape, the fish-tail seems to be preferred. In 1878 Thornycroft introduced a patent steam steerer, which is now universally used in first-class boats. In 1879 Yarrow introduced the bow-rudder, which is now universal in the large boats. This rudder is hauled up like a center-board when not in use, and is so connected to both the hand and steam gear of the after rudder that the two can be used together or separately at will. The bow-rudder is considered one of the most important of the improvements, as aside from the increased turning power it gives full control of the boat under sternway.

The plates and frames of the boats were at first simply cleaned and carefully painted, but since 1877 all the material is galvanized.

In the first Norwegian boat, only the fore and after peaks, engine and boiler room were permanently decked over, the remaining spaces being covered with movable plates. In the next boats, however, and universally since, the decking is complete fore and aft. The Lightning carried a booby aft in order to allow standing erect in the cabin, but since then this arrangement has been suppressed, the constant tendency being to keep everything possible as near the gunwale level as may be. As a rule, the boiler and engine room sections of the boats are the highest, except, of course, the pilot-house. The German first-class boats even succeeded in carrying a flat deck fore and aft, with a crown only slightly greater than the ordinary deck-rule. Sky-lights are carried by these boats with battle-plates provided underneath.

The first armament, as before stated, was the towing torpedo, towed from the top of the smoke-pipe in the Norwegian boat and from a permanent staff in the others. The inefficiency of this weapon being soon discovered, it was replaced by the spar torpedo, boats as a rule carrying two spars launching from the bows. About 1877, the spar torpedo gave way to the Whitehead, with which the Lightning was provided. This torpedo was at first (on the Lightning and boats of her class in *England*) discharged from the Whitehead torpedo gun by compressed air acting on a piston against the rear of the torpedo. The gun was mounted in the bow and pivoted so as to give an arc of discharge of about 270°. Two reserve torpedoes were carried on trucks just abaft the gun. By this method a good train was obtained without turning the boat, but it left all the torpedoes up in the air as an element of great danger in case of a torpedo being hit by a projectile, and for this reason the system was never favored outside of England. In all other boats the torpedo is discharged from tubes built into the boat and opening near the water-line forward, like immense hawse-holes. The discharge through these tubes is, in the first-class boats, by compressed air, as with the gun. Two tubes are carried with two reserve torpedoes, which are carried in the men's quarters amidships and bulkheaded as an additional protection. They are raised by radius-rods to the loading position. In the late and large boats the discharge tube is doubled in length with a gate in the middle, the reserve torpedoes being carried in the after half, so that the reloading is simplified. In both methods the men are not exposed nor are the torpedoes in reloading. In all cases, the tube is considered to furnish sufficient protection to the torpedo within it. In the second-class boat all of these methods were found to entail too much weight, and so could not be applied. In 1877 Thornycroft invented a cage hung from davits which worked like monitor davits. The cage was carried amidships so that when lowered the torpedo went just under water, and, laid in a fore and aft line, it was discharged by starting ahead under its own screw. This system was found to be ineffectual, as it necessitated slowing down the boat to a speed of not over three knots. In 1870 Yarrow introduced a system of steam discharge. The forward deck of the boat is shaped into two parallel troughs with covers that hinge and clamp. The torpedoes stow permanently in these troughs, the rear end resting against a piston-head, which is the discharger. The piston itself is simply a hollow tube encased, the small size of the boat and the angle of discharge bringing its position in the boiler-room close to the boiler, so that it is always warmed and ready to develop the full power of the steam. Steam is injected when desired and, after the discharge, is exhausted into the condenser. This apparatus is compact and

light. It gives to the bow of the boat a turtle-back deck, which in so small a boat is rather an advantage.

The water-tight division of the Norwegian boat consisted of six compartments, viz: Fore-peak, used as a store-room; fore-sheets, open and provided with seats for the crew; pilot-house, covered with $\frac{3}{16}$-inch plate; boiler and engine room in one and covered with $\frac{3}{16}$-inch plates; stern-sheets, open and provided with seats; after-peak, used as a store-room. As the boats increased in size and were improved this compartment division increased until, in the present first-class boats, it is usually as follows: Eight full, and 2 or 4 partial compartments (bunkers, &c.). The full compartments are, fore-peak, or collision compartment, unused; forward compartment, used as a store-room; berth-deck, for the crew, and also containing the reserve torpedoes; smoke-box room, containing the forward end of the boiler; boiler-room (in the Yarrow boats this compartment is subdivided as will be hereafter explained); engine-room, officers' quarters; after-peak, used as a store-room.

Important modifications have been introduced to provide for draft, safety of firemen, and rapidity of raising steam. Provision is made for exhausting the steam from the boiler, either directly into the condenser or directly into the air. Bilge-pumps and steam-ejectors are provided for clearing the compartments of water, and arrangements are made so that all the pumps may be put at this work, as well as from 2 to 4 hand-pumps. Water entering any of the compartments runs through valves in the bulkheads to a well in the engine-room, although where ejectors are provided the compartments may be emptied independently. In the bilge of the boiler-room the water runs through pipes to prevent carrying dirt to the pumps. In the second-class boats an arrangement is provided for taking steam from a ship's main boiler to aid in getting up steam rapidly. This arrangement consists, in the main, of an injector pipe entering the bottom of the boiler from a valve on deck to which a flexible pipe runs from the ship's main boiler; a branch also runs from this valve to the ventilator engine. The boiler being filled and fires started, the steam is turned on, thus rapidly heating the water in the boiler, and at the same time pushing the fire by giving a draft. Steam may be raised to 60 pounds in about ten minutes.

Thornycroft's invention for preventing a rush of steam or flame into the fire-room in case of a leak into the fire-box or a back pressure consists in an arrangement of flaps hung at the front of the ash-pit in such a manner that the air-pressure in the air-tight fire-room keeps them open; on a sudden back draft, however, they automatically shut; the furnace door secures with a strong spring catch. To prevent overpressure in the fire-box from a rush of steam, a connection is made by a pipe from the ash-pit to the deck, closed at that point by a spring valve which lifts under high pressure.

Yarrow's method of providing for this contingency is quite different. In his boats an air-tight bulkhead extends from the front edge of the boiler to the sides of the boat, thus making a separate boiler and fire room. The ash-pit is entirely closed in front (of the boiler) and is open at the rear directly under the boiler. In the bulkhead, on either side, is a manhole provided with a flap similar to the Thornycroft one. The pressure in the air-tight fire-room, as before, keeps these flaps open and a sudden back pressure closes them. The great advantage of this system is that it provides for a shot entering the boiler, which the other does not. Thornycroft has coal-bunkers on each side of the boiler. With Yarrow's arrangement this is not done and the boiler-room necessarily becomes a clear waste space, reducing very materially the coal supply. This was one of the principal faults of the Batum. With both these inventions no proviso is as yet made for the case of an open furnace-door when an accident occurs.

Yarrow introduced an arrangement to provide for the case of leak occurring, which endangers the fires by the water rising in the boiler-room. In this the whole fire-box is encased up to the water-line, the draft passing inside the casing, and the furnace-door is made water-tight. The water is thus kept out of the ash-pit and furnace, and time is allowed for feeding a full supply of coal, amounting to nearly half a ton, which is sufficient to run the boat 40 miles. The door is then shut, and thus steam is maintained for running and pumping until clear of danger. Yarrow has also introduced improvements in the details of the furnace, fire-box, and tubes, so as to greatly remedy, if not cure, the liability to leak when sudden changes of temperature give rise to unequal expansions and shrinkages. Arrangements are made for sweeping out the tubes when running. The smoke-box doors are covered with asbestos, and so arranged as to open independently, permitting the firemen to shelter themselves behind one door while sweeping out the tubes of the other half of the boiler. This necessitates a great reduction in the steaming, and the use of the natural draft alone. Steam pressure is lost during the operation.

TORPEDO PINNACES.

The second-class boats are in no way fitted for the general service of a ship, and when carrid by a man-of-war must be kept like the rest of the armament for the

special service for which they were designed. This has caused some dissatisfaction on the part of naval officers, and in point of fact the scope of the utility of these boats is clearly brought in question in the German Reichstag report, which intimates that the work of providing the ironclads with special torpedo-boats has been partially stopped.

Yarrow & Co., to meet this dissatisfaction, have designed a special form of steam-pinnace, intended to be equally well adapted for guard duty, torpedo work, and general service. The dimensions of this boat are: Length, 54 feet; beam, 9 feet; weight complete, with torpedo armament, 10½ tons; horse-power, 150; speed, 15 knots. The boat is of steel, and has open stern-sheets of the ordinary steam-launch pattern. In the bow a Whitehead launching-tube is fixed, which may be unshipped if desired and replaced by a gun or by freight. The reduction in speed is made up by increased handiness, and from the description it would seem to be a more desirable pattern for ship service than the second-class boat.

THE BATUM.

This boat is 100 feet long, 12 feet 6 inches beam, and has a load draught of 2 feet 8 inches forward and 4 feet aft. The hull is built entirely of steel. The thickness of the bottom plates and the middle strake of the deck plating is about $\frac{1}{4}$ inch (No. 8 wire gauge); the other plating is much thinner. The bottom of the boat is quite flat, there being no keel whatever, in place of which there is a slight rounding.

This arrangement is considered very faulty by Lieutenant Sazaremy, of the Russian navy, who commanded the Batum on her passage from London to Nickolaieff, on account of the tendency of the boat to roll and to list quickly. He advises the attachment of a keel of about 9 inches depth, together with a slight modification of the bottom lines.

The boat is divided by seven bulkheads into eight water-tight compartments, as follows: Fore-peak, forward compartment, torpedo and berthing room, smoke-box room, boiler and fire room, engine-room, officers' room, and after-peak.

Nothing whatever is stowed in the fore-peak, which is connected with the forward compartment by a manhole.

At sea this compartment was almost always full of water, partly on account of defective riveting of the bottom plates, partly through defective jointing of the torpedo tube with the bow-plates.

In the forward compartment, the torpedo magazines were stowed on one side, paint and oil on the other.

In the berthing-room are eight bunks at the sides, in two tiers, the galley, a machinist and carpenter's work-bench, a chest for the clothing of the crew, and a water-closet. This compartment is also the torpedo-room, and carries two torpedoes, the air-pump, and the regulator.

Between the boiler-room and the berthing-room is the smoke-box room, where the fire-tubes are cleaned. In order to do this work a manhole is cut in the bulkhead.

The boiler and fire room is cut in two by the Yarrow compartment.

Lieutenant Sazaremy states that in all his experience with torpedo-boats he has never seen the necessity of this arrangement, which possesses several objectionable features. Leaving out of consideration the special idea for which it was introduced, he found that it was impossible to stow any coal in this boiler-room, as it would interfere with the draft going to the ash-pit, and so would affect the steaming power. As in the passage from London there never was a necessity for carrying high steam, and so a minimum of coal could be carried, he found it barely possible to stow 3 tons. If it is necessary to provide for the contingencies for which the modification was introduced, Sazaremy considers the Thornycroft system to be sufficient, in which case it is possible to carry 4 tons between the boiler and the side of the boat. No coal-stowing place is even provided in the Batum in the fire-room. During the passage it was necessary to carry about 4½ tons in sacks stowed on each side up to the deck-beams, and piled on the fire-room floor to a height of a foot and a half, leaving only sufficient floor space to work the fires and give free space to the draft from the ventilator to the manholes in the bulkhead. As the ventilator was secured to the engine-room bulkhead, quite a wide passage had to be left free. If the ventilator had been put nearer to the forward bulkhead, sufficient room would have been secured to put up permanent bunkers, whereby the disagreeable whirling of coal-dust about the fire-room would have been avoided, and the disagreeable draft which affected the breathing of the men would have been stopped. If such a ventilating arrangement be adopted it can also be made much smaller, as in such a case it would not have to keep the whole fire-room under pressure.

In the engine-room are the main and auxiliary engines, a condenser, a cistern for fresh feed-water, two tanks for oil and tallow, and several other necessary attachments. Over the main engine is a sky-light of oval section, surrounding the cylinders, as the latter rise 1½ feet above the deck. In the after part of the engine-room is the hatch-

way and ladder. The different parts of the engine are very compact. The tubes of the condenser may be shifted without moving it from its place.

Sazaremy considers that the sky-light or hatchway should be made larger, as the machinist, when working the engine, does not stand in that space, but under the deck, where he is very much hampered by being obliged to stoop; especially is this an interference in stopping or altering speed. Another objection to this compartment is that no ventilation is provided for it. During the trip from London the temperature in this room rose to 156° Fahrenheit several times. No connection can be made with the fire-room for ventilating, as the great amount of coal dust flying about there would soon interfere with the working of the engines. If Thornycroft's system be adopted, not only can coal bunkers be provided, but the bulkhead may be taken down altogether without sacrificing the buoyancy of the boat. A sill 1½ to 2 feet high might be run across, which would be sufficient to keep water from one compartment entering the other.

In the officer's room are three bunks, a dining table, washstand, wardrobe, clothes chest, and water-closet.

In the after peak are five water-breakers, two chests for provisions, two rope-reels, spare parts of engine-gear, and the fighting-tiller.

Sazaremy suggests that if tanks shaped to the boat's contour be substituted for the breakers, and several of the useless things be removed from this compartment, it would give plenty of room for a ton of coal.

Like all of Yarrow's boats, the Batum has a very large turtle-back forecastle, extending fully one-third of the boat's length. At the rear end of this is the pilot-house. The roof of this house may be raised or lowered by means of screws. Under ordinary circumstances, it stands about 4 inches above the edge of the house, so that even at night a clear view is given all round the horizon. The upper edge of the pilot-house is 6 inches above the center-line of the turtle-back.

Sazaremy considers that it would be well to give the turtle-back still more crown, so as to give better ingress from the rear into the men's quarters. A corresponding increase in height of pilot-house is also considered advisable in order to keep out the spray and sea. The elevated part of the deck should be carried aft to the compartment bulkhead in order to give more head-room on the berth-deck.

In the pilot-house is the fighting-wheel, which can be used on both after and forward rudders. There is abundance of room on the platform for both the helmsman and commander. On the platform is a telegraph and speaking-tube for the engine-room and the valve for firing the torpedoes.

Under ordinary circumstances, the bow rudder is kept hauled up in its well, and the steering is done by the hand-wheel on deck. If, however, it is necessary to use the bow rudder the steam fighting-wheel must be used, as the coupling is to that arrangement.

Water-clearing is provided for by six ejectors, one in each compartment except the peaks.

The ventilation of the berth-deck is accomplished by a small ventilator in the pilot-house roof and by two pipes just under the deck, one end of the pipes being in the berth-deck and the other in the smoke-box room. The draft thus furnished by the difference in the temperature exhausts the foul air from the berth-deck.

On deck forward are two cranes for shipping the torpedoes.

Sazaremy considers the cranes too weak, and a tackle insufficient for the heavy work, for which a little steam windlass should be provided.

The boat carries one anchor of 200 pounds weight and 600 pounds of ⅞-inch chain.

Sazaremy considers this sufficient for the trip of the Batum, as the anchor always held well and the chain never broke. In general, however, he considers it better to have two anchors and chains. He also considers it better to have a windlass for getting up anchor, as it always required all hands to get it in in getting underway.

The boat carried a Thompson compass, which Sazaremy considers should be replaced by a liquid one, as the short rolls of the boat frequently would spin the card around.

The Batum carries a light pair-oared yawl, 10 feet long, 3½ feet wide, and weighing 140 pounds. It is built of cedar, and has two air-chambers. It can carry six persons, and when filled with water will support four. This boat suffices for the service of the Batum.

The main engines consist of a two-cylinder compound direct-acting engine. Diameters of cylinders, 12½ and 21 inches; stroke, 17⅛ inches; indicated horse-power, 500. The condenser is fore and aft on the port side, and the fresh-water tank on the starboard. By this fore and aft arrangement the tubes may be changed without moving the condenser, but in order to do it the greater part of the arrangements in the officers' quarters on the port side must be removed, in order to get at the manhole in the bulkhead and do the work.

Sazaremy thinks this arrangement a very faulty one, as, when the condenser is full, the boat has a list to port and her speed is affected. He recommends putting the condenser in the forward part of the officers' quarters athwartships, with the feed-pump

at one end of it, there being plenty of room for this arrangement; then by putting the fresh-water tank athwartships in the forward part of the engine-room so much room would be gained in this compartment as to allow of the extension of the coal-bunker space so as to give the boat a supply of from 10 to 12 tons.

The piston-rods are hollow; the upper ends of the cylinders are braced from the skylight frames, and in this manner the jar of the engine is quite prevented. All the frames in the shaft-alley are utilized as thrust-bearings. The auxiliary engine works the circulating-pump, feed-pump, air-pump, and, in case of necessity, the bilge-pump. The injection-opening has two Kingston valves, through one of which water goes to the feed-pump, and through the second to the condenser.

This opening should be nearer the bottom, as it rolls out of water in a seaway, and so affects the vacuum.

In case the auxiliary or the condenser breaks down, arrangements are made for working under high pressure alone. The screw is about one foot abaft the rudder.

The screw is neither protected in rear nor underneath. The slightest contact aft with anything, ground, collision, &c., is sufficient to either bend or break off the thin blades. Sazaremy states as his experience that this touching aft is a matter of very common occurrence in torpedo boats, and considers that the most careful commander cannot avoid it in peace times, let alone war, where barricades, nets, &c., have to be contended with. The experiments of the French with regard to speed and turning power with the screw before and abaft the rudder have proved that the speed is not in the slightest affected by having the screw forward; so that even if it were at a sacrifice of a half a knot, Sazaremy considers that the protection of the screw demands that it should go as in Thornycroft's boats.

The boiler is of the locomotive type, cylindrical and steel; length 15 feet 5¼ inches diameter, 4 feet 4 inches, and contains 686 gallons. The fire-box is copper; the grate-bars, 96 in number, are 2 feet long. Heating surface 400 square feet; grate surface, 29.3 square feet. The boiler was tested to 260 pounds, the normal pressure being 130 pounds. There are 176 fire-tubes of brass, 9 feet 3¼ inches long by 1¼ inches outside diameter.

The tubes are too small, as they become very much clogged with soot in a very short time, even when using the best coal. They have to be cleaned about once in 7 or 9 hours, and during the operation the steam falls and the effectiveness of the boat is sacrificed.

The boiler is fed by a feed-pump and an injector; a hand-pump is also provided, and there is an opening in the top of the boiler so that it may be filled from deck.

On torpedo boats a fresh-water feed is necessary. On the Batum, the tank only held sufficient for 4 hours steaming at moderate speed. This quantity should be increased. On the trip from London Sazaremy always started with boiler and tank filled with fresh water, and then by taking a moderate quantity of salt water he was enabled to get along without fouling the boiler.

The boiler is provided with one manhole and nine handholes for cleaning it. These holes are quite insufficient for the purpose, as all parts of the boiler cannot be reached. A manhole large enough to admit a boy should be made.

The boiler has two chimneys, symmetrical, situated athwartships. These chimneys were originally 5 feet high, but in Fiume the height was increased to 7½ feet, as they shipped a great deal of water. With a forced draft, great quantities of ashes are thrown from the chimney, so that in a very short time everything gets covered with soot. This does not happen with a natural draft.

The Batum carries four torpedoes; two in the launching tubes and the other two in troughs built for them on deck.

Much trouble was experienced with the torpedo arrangements which were put on board by Whitehead at Fiume. The torpedoes in the troughs have to be put by hand into the launching-tubes, which is extremely difficult work for the few men available. The air accumulators leak badly from the vibrations of the boat acting on the valves, and once empty they cannot be recharged under speed, owing to the vibrations and other defects. The torpedo in the tube is only held fast at the rear end of two stoppers, leaving the other nine-tenths of it loose in the tube, so that the vibrations of the boat injure it. In a run from Nickolaieff to Odessa with the torpedo in place, the following damage was done: The rudder part of both torpedoes was bent somewhat sidewise. The screws which fasten this part to the end piece had slacked up. The rudder-head of one of the torpedoes was doubled up. In one torpedo the screws connecting the engine section with the air-chamber were slacked up. The pendulum had hammered into the wooden bulkhead about one-eighth of an inch. This damage was done by a shaking up of three hours. Sazaremy considers that the mouths of the tubes ought to be made to take the contour of the boat's bow, as it will make no difference in the aim of the torpedo under any circumstances. Although the mouths of the tubes are closed by stoppers they are not perfectly water-tight, and a good deal of water enters which finds its way into the regulator, and often into the tube between the regulator and accumulator. In a trial made it was found that the torpedo could not be

launched on this account. This trouble is serious, since before the torpedo can be fired the mouths of the tubes must be opened, and thus a quantity of water is allowed to rush in. That these difficulties have not been discovered before is due to the fact that heretofore experiments have been carried on in still water and at low speeds. Sazaremy insists that all experiments with sea-going boats should be carried on at sea.

The itinerary of the trip of the Batum to Russia is as follows:

Ports.	Miles.	Hours.
London to Brest	470	43
Brest to Ferrol	340	46
Ferrol to Lisbon	340	36
Lisbon to Gibraltar	300	27
Gibraltar to Algiers	430	36
Algiers to Bona	245	22
Bona to Messina	450	33
Messina to Brindisi	270	24
Brindisi to Fiume	360	.....
Fiume to Gravosa	270	24
Gravosa to Zante	330	.....
Zante to Syra	270	.....
Syra to Constantinople	330	.....
Constantinople to Nickolaieff	430	.....

Mean speed for the whole trip of 4,835 miles, 11.1 knots.

During this trip the boat experienced all sorts of weather, steaming against a full gale in the Bay of Biscay. Only once was she obliged to stop *en route* to cool a bearing. She was tested under sail alone, and found to work thoroughly well. The small supply of coal was all that prevented a much faster record.

According to the contract, the trials previous to delivery in London were to be made with the boat light, and it was made with the least weight possible aboard. Indeed, so little coal was carried that the boat had scarcely enough to bring her back from the measured mile. Under these circumstances, she obtained a mean speed of 22.16 knots for six runs over the measured mile, carrying a pressure of 130 pounds. Experiments were made to establish the flotation elements of the boat with the following results:

Fully laden, at a displacement of 48.2 tons the metacentric height was 2.1 feet.

At the load-line the boat required 1.8 tons for an inch of immersion.

At the load-line the center of gravity was 3 feet 6 inches from bottom of keel or near water-line.

At 45 tons displacement, center of gravity was 3 feet 1½ inches from bottom of keel.

The maximum stability was reached at a heel of 50°. Lever arm, 1.35 feet.

At 10° heel the gunwale was at the water-level.

The Batum was given a trial at Nickolaieff, with full outfit aboard. Under these conditions, with 115 pounds steam, 332 turns of the screw, she made 15½ knots over the measured mile. Much of this great fall in speed was attributed to poor coal and bad firing. In a trial run from Nickolaieff to Odessa and back, a distance of 156 miles, with a fresh breeze, the mean speed was 13.7 knots.

In closing his report Sazaremy sums up the faults of the Batum: (1) Too low a coal supply, only sufficient for 350 miles; (2) too low speed when fully equipped. He recommends for future boats—

(1) A length of from 100 to 120 feet to allow heavier machinery and more coal.
(2) A beam of 13½ to 14 feet.
(3) Better shaped upper works.
(4) Simpler and lighter torpedo apparatus.
(5) A larger boiler with two furnaces and a more powerful engine.
(6) To be more solidly built; the bottom plates one-fourth inch and the others one-eighth inch.

Finally, the contract should stipulate for trials at the deep-load line, the engines not to be overworked on the trial, and a mean speed of 18 knots to be maintained for four hours. Runs of 20 miles should not be allowed, as they are deceptive.

THE SUCHUM.

This boat, built by Thornycroft, is one of four of an enlarged type of Batum, two of which were ordered from English and two from French firms. The dimensions of the boat are: Length, 113 feet; beam, 12 feet 6 inches; depth of hold, 6 feet 6 inches; draught, 2 feet 6 inches forward and 6 feet aft; displacement, 60 tons; diameters of cylinders, 14½ and 24½ inches; length of stroke, 15 inches; heating surface, 1,119 square feet; grate surface, 30 square feet; indicated horse-power, 750.

Many of the improvements suggested by Lieutenant Sazaremy have been introduced in this boat, which otherwise is quite the same as the Batum, except that she carries two Hotchkiss 37-millimeter revolvers, one on each side at the rail just abaft the pilot-house. The first trial trip of this boat took place July 10, 1883, and had for its object to ascertain the maximum speed of the boat when carrying a full outfit weighing 6 tons and coal enough to steam 1,000 miles, at a speed of not less than 10 knots.

The weights carried were as follows:

	Pounds.
Torpedo launching gear	5,119
Four Whitehead torpedoes	3,512
Torpedo air-pump	511
Two Hotchkiss guns	715
One hundred Hotchkiss projectiles	219
Anchor gear and windlass	415
Boat	101
Complement of sixteen persons	2,554
Drinking water	263
Total	13,409

To this must be added 10 tons of coal, making a total of 16 tons. The displacement of the boat with this load was 59½ tons; draught, 2 feet and 5 feet 10 inches. At these lines she made a mean of six runs over the measured mile of 19.49 knots, and a mean of three hours' run of 18.96 knots. The engines worked well; the mean revolutions on the measured mile was 414.75, and during the three hours 403.88. The maximum indicated horse-power was 720. Coal used was 1 ton per hour for 18.9 knots. Steam pressure, 130 pounds per square inch.

The second trial had for its object to ascertain if the coal was sufficient to steam 1,000 miles at a speed of not less than 10 knots. The boat was brought to the same lines as before, carrying 9 tons of coal in the bunkers and 1 ton in bags The run lasted from 10.46 a. m. to 8 p. m., during which she made 101.11 sea miles, at a mean speed of 10.83 knots, and a total coal consumption of 1 ton short. Steam pressure, 110 to 118 pounds; revolutions, 222 to 227. The requirement of fresh water was a great drawback, as the boat's regular supply was only sufficient for 50 sea miles. Extra fresh-water tanks were carried during the trial, the total amount required being 111.32 cubic feet.

The boat was then submitted to a series of turning trials, with the following results, at a speed of 18 knots:

Both rudders: Time to port, 1 minute 20 seconds; diameter of circle, 588 feet.

Both rudders: Time to starboard, 1 minute 35 seconds; diameter of circle, 840 feet.

One rudder: Time to port 1 minute 56 seconds; diameter of circle, 663 feet.

One rudder: Time to starboard, 2 minutes 50 seconds; diameter of circle, 964 feet.

The boat was then given several trials, with an addition of weights of 5.2 tons, representing the material necessary for a long trip, as follows:

	Pounds.
Boiler covering	1,233
Six boxes Hotchkiss shell	329
Boat and gear	165
Masts and sails	708
Flag chest	51
Chart table	66
Side curtains of sail cloth	71
Spare anchor	199
Drinking water	848
Two spare fresh water tanks and pipes	120
Reserve fresh water for boiler	998
Fresh food, three days	199
Sea stores for eight days	479
Baggage of crew	658
Baggage of officers	399
Navigating instruments and charts	299
Lanterns, flags, stationery, &c	199
Boatswain's stores	686
Engineer's stores	2,860
Oil and tallow	419
Small articles undetailed	299

With the entire load the displacement of the boat was 64 tons, and with this she made a mean speed of six runs of 17.93 knots, with 404.3 turns and 130 pounds of steam.

By test it was found that she would steam 252 knots at a speed of 15.45 knots; 372 knots at a speed of 23.39 knots; 189 knots at 18.9 knots, and 1,000 knots at 10.8 knots.

A test was made of cleaning the fire tubes while running. For this the whole forward part of the smoke-box doors and the smoke-box itself is covered with asbestos, and the doors are arranged to open independently. The man cleaning the tubes shelters himself behind the closed half of the box. In the test the steam was allowed to fall to 40 pounds, and the engine was slowed to 100 turns; 35 tubes were cleaned in a quarter of an hour; the temperature in the compartment, which, at the commencement, was 113° Fahrenheit, sank during the work to 88°, and the steam fell to 30 pounds. No trouble was experienced with the gas, as there was a perceptible draft from the berth-deck, through the manhole in the bulkhead, and into the smoke-box.

The boat made a very successful passage from London to Nickolaieff. The side curtains were found to be very useful in keeping water from slopping into the engine-room. In a heavy cross-sea the seas often swept over the roof of the pilot house, but in a regular sea she was very buoyant.

At Nickolaieff she was given another trial, when, over a 2-mile course, the highest mean speed that could be reached was 16.21 knots. This was attributed to poor coal and inefficient firing.

The Hotchkiss guns were tried at sea, and found to work efficiently, there being no recoil effects whatever noticeable.

THE CHILDERS.

This boat, built by Thornycroft for the Australian Government, is the same size as the Suchum. Her dimensions are: Length, 113 feet; beam, 12 feet 6 inches; draught aft, 6 feet; displacement, 58½ tons; diameters of cylinders, 14½ and 24½ inches; stroke, 15 inches; heating surface, 1,119 square feet; grate surface, 30 square feet. She carries four Whitehead torpedoes and two Hotchkiss guns, 37 millimeters.

On her official trial the maximum speed reached was a little over 19 knots. During a three hours' trial, with an outfit of 14½ tons, she reached a mean speed of 18¼ knots. During this trial it was ascertained that at a speed of 11½ knots she burned 203 pounds of coal per hour. The supply of the boat being 10 tons, it is enough to carry her 1,270 knots at this speed.

THE LATEST GERMAN BOAT.

The Berliner Zeitung of July 10 contains the following telegram from Pillau: "Day before yesterday the first of the new boats building at Schichau was tested at this place. With complete outfit and stores and coal for steaming 1,000 miles she attained a maximum speed of 20¼ knots. On the last run the rudder was twisted by being put over too quick, and the trial was stopped. Yesterday it was resumed and this time a run was made from Pillau to Neufahrwasser and return, a distance of between 50 and 60 miles. The run over was made in 2½ hours and back in 2½ hours. Maximum speed attained, 21¼ knots. Indicated horse-power, 1,000. This is the highest speed for prolonged running yet attained by a torpedo-boat."

BEHAVIOR OF FRENCH TORPEDO-BOATS AT SEA.

In April last the evolutionary squadron left Toulon for the eastward in the teeth of an easterly gale, the ironclads being accompanied by two torpedo-boats. The squadron consisted of the Richelieu, Marengo, Trident, Duperré, Redoutable, Vengeur, and Tonnerre, with the dispatch boats Hirondelle and Renard, and torpedo-boats Nos. 64 and 65.

The dimensions of these boats are: Length, 108 feet; beam, 10 feet 10 inches; draught, 2 feet 10 inches; displacement, 46 tons. They carry a coal supply sufficient for 600 miles at a speed of 12 knots.

Arrived off Hyéres the two monitor vessels Tonnerre and Vengeur had to run in to an anchorage, being unable to keep their stations on account of the sea. The admiral had reduced the speed of the squadron from 10 knots to 8, and then to 6. It was found impossible to reduce the speed of the torpedo-boats below 8 knots, so they kept that speed until some distance ahead, and then stopped and dropped back to their stations. No difficulty whatever was found in navigating the boats in the heavy sea. Head to it, they rose to the sea with great buoyancy, and all the deck abaft the pilot-house was clear of water and could be used as a promenade with safety. Broadside to the sea the rolling was heavy, but not so much as to hamper the movements. No trouble whatever was experienced with the screw, as it was out of water so short a time that there was no racing of any consequence. The men's quarters were, however, very uncomfortable. It was impossible to use the galley, and the vibrations were so great as to cause seasickness. Both boats were somewhat troubled with leaky rivets. Steering with both rudders and with the after one alone was tried and the boats in all cases answered the helm with the greatest readiness.

THE FRENCH SYSTEM OF NUMBERING BOATS.

In the French service second-class boats are numbered consecutively up to 60. All above that number are first-class boats. No. 65 was launched in June, 1884.

THE SCOPE OF GERMAN NAVAL COAST DEFENSE SUPERINTENDENCE.

MARCH, 1884.

"It is the expressed will of His Majesty the Emperor, with regard to the coast defense, that hereafter the navy is to be intrusted not only with the defense of the two great dock-yards, but also with the maritime defense of Prussian fortresses on the coast and seaports. It is considered that for a thorough defense the army and the navy should work together according to clearly laid down rules, and to the navy should be given the supreme control of all maritime operations. From this time forward all harbor entrances must be in a condition to be immediately protected by mines and troops. Heretofore all this work having been intrusted to the army, the engineers during the operation of mobilization were overburdened. In the future, however, the navy, through its interest and technical skill, can readily keep harbors and channels open for the passage of friendly vessels up to the last moment and close them quickly and certainly when necessary. Again, the introduction of torpedoes proper into the cadre of army weapons reduces the general efficiency of the service, as has been shown in operations with mines. The army commandant of a coast place would find it difficult to properly control the naval *personnel* which in any case is necessary for the service, and he could but illy superintend the movements of torpedo flotillas. Finally, in order to establish communications with the naval outposts, extra steamers under army control would be necessary, which would complicate the service. Requisitions for merchant vessels and materials could not be wisely filled under army superintendence, and a harbor once blocked by mines, all movements, no matter how urgent, of naval vessels, could only be undertaken after arriving at a special understanding between the army and the navy."

MODERN ARMOR

FOR

NATIONAL DEFENSE

PRESENTING PRACTICAL INFORMATION ABOUT MATERIAL, METHODS OF MANUFACTURE, COST, DEVELOPMENT, TESTS AND APPLICATION, EFFECTS OF FIRE, RESISTANCE OF PLATES, AND A COMPARISON OF THE RESULTS THAT HAVE BEEN OBTAINED AT THE MOST IMPORTANT COMPETITIVE TRIALS, TOGETHER WITH STATISTICS

BY

WILLIAM H. JAQUES

LIEUTENANT U. S. NAVY.

ILLUSTRATED.

4953 OR——13

MODERN ARMOR.

By LIEUT. W. H. JAQUES, *United States Navy*.

[The following treatise, prepared by Lieut. William H. Jaques, United States Navy, secretary of the committee (and to be published by G. P. Putnam's Sons, New York, as a number in The Questions of the Day), gives, as its title indicates, a review of the whole question of armor, steel or iron. It is clear, condensed, and comprehensive. Its positions are fortified by the highest authorities.—CHAIRMAN COMMITTEE.]

Steel and iron! To which of these should be confided the trust of defense? Economic as well as military reasons must govern the decision. Reading the various statements and reports upon the relative efficiency of different materials for protection against the fire of modern ordnance, it is most difficult to reach a conclusion as to the superiority of any one material over another for this purpose. Anything from street rails to the best forged special steel is suggested as adaptable to a particular purpose, but in the majority of instances no definite conclusions are presented.

It is not the intention of these few pages to follow the development of armor, or to present full descriptions of its manufacture and the experiments with it. These have been ably presented by Capt. Orde Browne, R. A., in numerous papers; by Lieut. E. W. Very, U. S. N., in his "Development of Armor for Naval Use," published by the Naval Institute in 1883; by Lieut. Emile Weyl, French navy, in "Questions Maritimes," published by Berger-Levrault, Paris, in 1885; and fully treated in my "Establishment of Steel Gun Factories," published by the Naval Institute in 1884. I am indebted to these authorities for assistance in the preparation of this paper, and I earnestly recommend them to all who desire to acquire exhaustive information on this special subject. In addition to the personal inspection of many targets, I have carefully searched the best authorities for the facts that would assist me to present the practical information relating to modern armor that appears at this time to be most needed.

To those who consider armor useless because the penetrating power of modern artillery is superior to the resistance of modern plates, I would call attention to the fact that circumstances attending target-practice on the proving-grounds—the fire normal, guns on fixed platforms, and the range only a few hundred feet—are very different from those in battle, where the range is great, the armor fitted to the fort or ship is constructed to present the least amount of normal surface, and the attacking gun and moving ship are ever changing their positions. According to Noble, one of the ablest English artillerists, a thickness of armor equal to one-half the diameter of the projectile will insure almost certain impenetrability in the ever-varying conditions of a battle at sea.*

*In a sea fight armor does not lose its power of resistance; the gun, on the contrary, loses much of its power in an attack. (Weyl.)

DEFINITION.

The term "armor" is at present applied to the metallic protection† of forts and ships which the increased power of modern artillery has rendered necessary.

KINDS.

There are four kinds—cast iron, wrought iron, compound* (wrought iron and steel), and steel. Cast-iron and wrought iron are now only used for forts. Compound and steel may be used for either forts or ships. Capt. Orde Browne classifies armor as *soft* and *hard*, "the former signifying armor which is perforated, and the latter armor which refuses to yield in this way and must be broken up."

MANUFACTURERS AND MODE OF MANUFACTURE.

The number of manufacturers of armor is exceedingly limited in consequence of the cost of plant, the skill and experience required, and the uncertainty of a market.

CAST-IRON ARMOR.

This is principally manufactured by Gruson of Buckau, near Magdeburg, Prussia. His method of manufacture is secret, but a chill mold is used, which renders the outer surface of the plate very hard, while the inner surface remains soft. Very gives the following description of the manufacture of Gruson chilled cast-iron armor:

The first operation performed at the Gruson factory, in the construction of an armored fortification, is to build a full-sized plaster model of the fort, each block being separately molded and put in place. From this plaster cast the exact shapes of the different curvatures are obtained, and the second part of the operation, that of making the chill mold, is then proceeded with. This chill mold is itself made of cast-iron, which is run in an ordinary sand mold, the latter having been made from the plaster mold, and forms the base of the main block mold. Upon the chill mold a sand mold is built corresponding to the remaining end, side, and interior contour of the block. What may be termed the trade secret in the construction of this armor rests entirely in the choice of the pig, its treatment in the furnace, and the care in the casting. Herr Gruson claims, and apparently with reason, that his factory is the only one in the world that can make such immense chill castings (ranging from 20 to 50 tons each) successfully. It is certain that the Russians tried repeatedly and unsuccessfully to make these castings without surface cracks; and when it is considered that it required years of practice to make perfect so small an object as a chilled 9-inch rifled shot, the skill and knowledge required for the operation can be appreciated. The pig metal being melted in the furnaces, is tapped off into a single large receiver,

†The main object to be accomplished in the development of armor is to protect the vulnerable things behind it. It must be remembered that the ultimate object of naval armor is to attain the greatest amount of protective power with the least possible weight, and since there is a minimum limit of space to be defended which cannot be reduced, the reduction of weight must be accomplished by a reduction in thickness. (Very.)

I wish to make it clear that it is so intolerable to have a hole made in a shield and to get a shell far through it so as to explode in the interior, that I look upon it as a certainty that armor should always be made hard enough to stop that. (Browne.)

If a projectile succeeds in completely piercing the side of a vessel an immense water-course is opened; if the breach is near the water-line very grave injuries are thereby caused, which, being of vital importance are especially guarded against by the application of armor, and these injuries become still more disastrous if the breach be opened by a shell piercing and exploding inside. A single blow well directed might suffice to disable an iron-clad. (Report of Italian Commission, 1876.)

*A few experimental compound steel plates have been mechanically manufactured, but the results of their trials have not been made public.

and from there is fed directly into the mold. When the latter is full, a surplus of molten iron is allowed to run around the upper part of the mold so as to retard the cooling of the unchilled portion. When the casting is cooled the work of the construction of the block is practically finished, for nothing remains except the ordinary finishing foundry work. The ends of each block are slightly hollowed, and when the blocks are put in position finally zinc solder is run into the cavity formed by the close-fitting adjacent ends of blocks, securing them together and thus avoiding all bolts or fastenings of any other description.

This armor is used for forts in Germany, Russia, Holland, Italy, Austria, and Belgium. It was at one time adopted for inland forts in France, but broke up so easily under the effects of *steel* shot that it was condemned and is no longer used.

Every experiment with the Gruson cast-iron armor shows the immense influence the curved surface has upon its resisting power, while its great weight and size, and the fact that the whole advantage of the chill is lost in the flat plates, unfit it for application to vessels. Again, it must be remembered that it never has been subjected to such severe tests as steel and compound armor have received, and although its cost per ton is less, the larger foundations necessary would make the final cost of the turret or casemate equal to if not greater than that constructed of steel.

The greatest thickness of cast-iron plates is 43 inches; weight, from 50 to 80 tons; price, from $150 to $200 per ton.

WROUGHT-IRON ARMOR.

At one time there were many manufacturers of wrought-iron armor in England, France, Germany, and Russia; but since 1879 it has been practically abandoned for ships, as it has been found that both compound and forged-steel armor possess from 20 to 25 per cent. greater resisting power for the same thickness. Although wrought iron is still used in England for forts, steel possesses many advantages. It is somewhat more costly per pound, but its power of resistance is so much greater than that of wrought iron that the plate-upon-plate system that will have to be adopted to get the required thickness with the latter, the increased length and cost of bolts, and the largely increased cost of transportation and fitting, tell heavily against wrought iron.*

Of the numerous plants capable of turning out wrought-iron plates, the principal manufacturers are: Charles Cammell & Co., Sheffield, England; John Brown & Co., Sheffield, England; Marrell Brothers, Rive-de-Gier and Couzon, France; Petin & Gaudet, Rive-de-Gier, France; Terre Noire Works, Terre Noire, France.

The greatest thickness of wrought-iron plates of guaranteed quality is 12 inches. Weight, about 40 tons. Price, from $220 to $336 per ton. As 12 inches of wrought-iron are easily perforated by a 6-inch high-power breech-loading rifle, more than one plate must be employed if the armor is to be at all efficient. The additional cost of fastening and sandwiching these will increase the cost of wrought-iron protection to more than that of the steel plate of an equal power of resistance.

COMPOUND ARMOR.

This term is applied to armor which is composed of a hard steel face and a wrought-iron back joined together, or of a hard steel face and a

* Foreign experts, as a rule, have always accepted the development of wrought-iron armor as a necessary evil, clearly foreseeing its limits. (Very.)

them must go through the plate. A new rule is about to be adopted, as follows: The gun shall be just able to pierce the plate with a chilled-iron projectile. The plate must remain on the target until after the second shot. None of the three projectiles must go through the backing.

In Italy there have been a variety of tests, but the latest are as follows: For the Italia, supplied in 1883 with English compound plates 19 inches thick, one shot capable of penetrating a wrought-iron plate of 25 per cent. greater thickness fired at the center of the plate. The shot must not go through. For the Lepanto, now being supplied by Schneider with steel plates 19 inches thick, three shots to be fired at the apexes of a triangle, each side of which is 2½ calibers of the projectile in length. The energy of the first shot to be that which is theoretically necessary to pierce an iron plate of the same thickness. The projectiles in the last two fires to have energy sufficient to pierce an iron plate of 25 per cent. greater thickness.

In consequence of the enormous cost of these tests (over $15,000), the Italian Government only test two plates out of the entire lot (1,800 tons); but they require that *every* plate shall have four test pieces cut from it, two from the outer and two from the inner corners, and the tensile strength, elongation, and elasticity of these specimens must average the same as corresponding test pieces taken from the plates subjected to the gun test.

EFFECTS OF FIRE.

Of the behavior of different kinds of armor under fire, Orde Browne says:

Wrought iron yields locally; it is punched or perforated, a clean hole being made in it. The rest of the target hardly suffers appreciably, except close to the point of impact. The plate yields at the back, opposite to the point of impact, by tearing in a cross or star line, letting the point of the shot through the center.

The *compound plate* yields mainly by cracking in radiating lines from the point of impact. In plates badly backed the plate bends slightly back, and very rigid shot occasionally get their points through; but when well backed the entire plate must be broken in pieces and displaced before a shot gets past it in any sense. In addition to the radial cracks, concentric ones are apt to be developed.

Solid steel, as made by Schneider, though rather less hard than the steel face of the compound plates, is, as a mass, more rigid. It admits the points of the shot at first with rather less resistance, but it does not yield at the points of impact even when badly backed, and is, therefore, less dependent on backing than compound armor. I have never known of a concentric crack being made in steel armor, nor of the point of the shot getting through until the plate was stripped off.

Chilled iron made by Gruson is very rigid. The shot never, I believe, gets its point even a single inch* into the metal. The shield transmits the shock through its mass, and must be broken up bodily. Chilled iron is used in large masses, and is best suited to resist single blows, especially in an oblique direction. Under the direct blows of heavy shot of high tenacity chilled iron breaks up. Cracks radiating from the point of impact are formed, and the whole shield breaks across.

Omitting, therefore, further consideration of wrought and chilled iron because of their want of sufficient power of resistance, let us notice the remarkable difference in the appearance of the steel and compound armor when under fire.

When a thick steel plate is completely perforated, Plate 27, the steel rarely shows a hole larger than the diameter of the projectile, which acts like a punch. From this hole cracks radiate.

In the compound plate, Plate 28, circular cracks appear in addition to the radiating ones, and a circular piece considerably larger than the diameter of the shot is driven from the face of the plate through the

*Up to the present time no projectile has ever penetrated a Gruson chilled-iron plate to a greater depth than 2.8 inches. (Griffen: "Our Sea-Coast Defenses.")

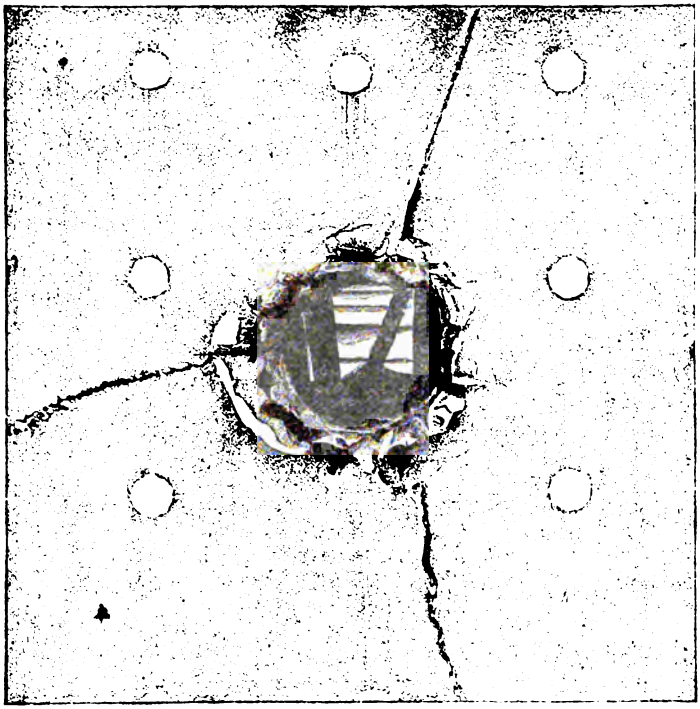


PLATE 27.

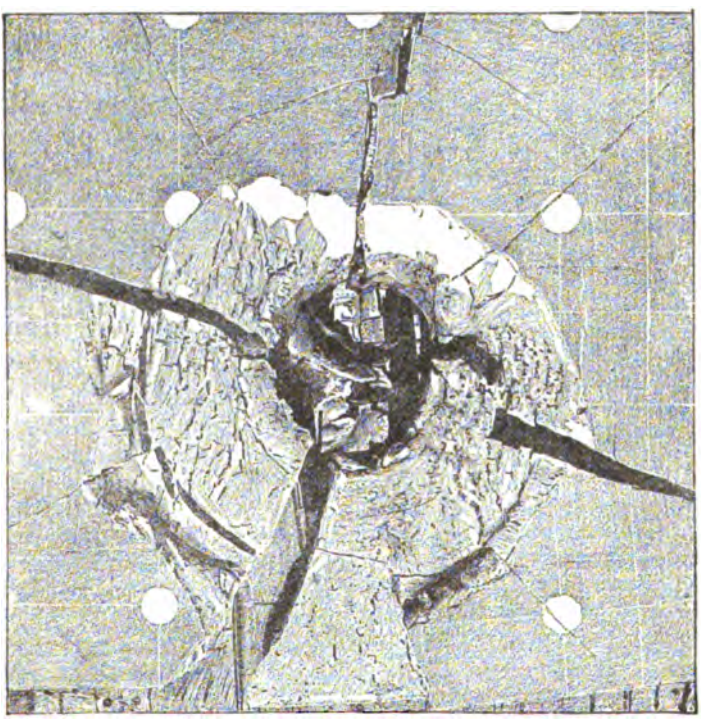


PLATE 28.

back, forcing the plate open laterally and increasing the opening rapidly in diameter as the rear surface is approached.

The face of the plate in either case is dished or bent in considerably unless the backing is absolutely solid; when the backing is not solid, the compound plate suffers far more severely than the steel—a matter of very serious importance in its application to the side of a ship.

COMPARISON OF STEEL AND COMPOUND ARMOR.

The steel face of compound armor contains about 0.7 per cent. of carbon, and its object is to deform or break up the projectile on impact, while the wrought-iron back holds the plate together and keeps the steel up to its work; the iron back is not expected to be of much value in keeping out the shot after it has penetrated the steel face. Major Mackinlay, R. A., thinks that compound armor has an advantage, because its face is so hard, but considers that the union of the two materials, steel and wrought iron, probably leads to complication and uncertainty in results.

Schneider steel armor contains about 0.4 per cent. of carbon and is very carefully tempered. The outer surface of the plate is slightly harder than the inner surface, and the object to be obtained is not only to destroy the shot on impact, but to present as great and nearly uniform a resistance as possible throughout the entire thickness of the plate, so that it may hold together till the shot is broken.

Compound armor, therefore, shows to better advantage, so far as a surface work is concerned, when the projectiles are poor than when they are good. This fact should not be forgotten, for great efforts are being made in Europe to develop projectiles. Whitworth, of Manchester, England, and Holtzer, of Unieux, France, produce the best at present; those of the latter are made of chrome steel.

In manufacturing compound plates, the principal difficulties to be encountered are in joining the iron and steel, and the difficulty is aggravated in joining steel and steel. Trials under fire develop a separation of the two metals, especially if the fire is oblique,* and a shot entering the back of a compound plate will penetrate the entire plate with very much greater facility than if striking the face, a fact which might be of importance in ships exposed to vertical or mortar fire. However good the iron for the back of the plate may be, it is rendered poorer by the reheating necessary to join it to the steel face, and the subsequent rolling has a tearing rather than a welding effect, because the two materials receive the work of the rolls in different degrees. This probably accounts for the fact that there is no compound plate in existence where the weld is perfect.

Curved plates, especially tapered and double curved (Plate 29), for which there is a continually-increasing demand, are particularly difficult and expensive in compound manufacture. If bent after the plate is completed, the joint is liable to be broken, and if the steel face is cast on after the plate is bent, it is difficult to get the right thickness (which is very important), and the steel cannot be worked sufficiently afterwards.

In the Schneider plates these difficulties do not obtain, as each plate is a single ingot of homogeneous metal, worked down under a hammer to the necessary thickness and curvature, the great power of the hammer (100 tons) making very few reheats necessary, which is of very great

* In all naval conflicts the great majority of hits will be oblique, for in addition to the permanent obliquity given to the armor in construction, there is the constant alteration in position between the vessels engaged. (Very.)

importance to the quality of the metal. Up to this time no double-curved plates have ever been subjected to target practice, and trials of this sort will prove very instructive.

One of the most important features in connection with armor is the manner in which it is fastened; for the artillerist not only strives to

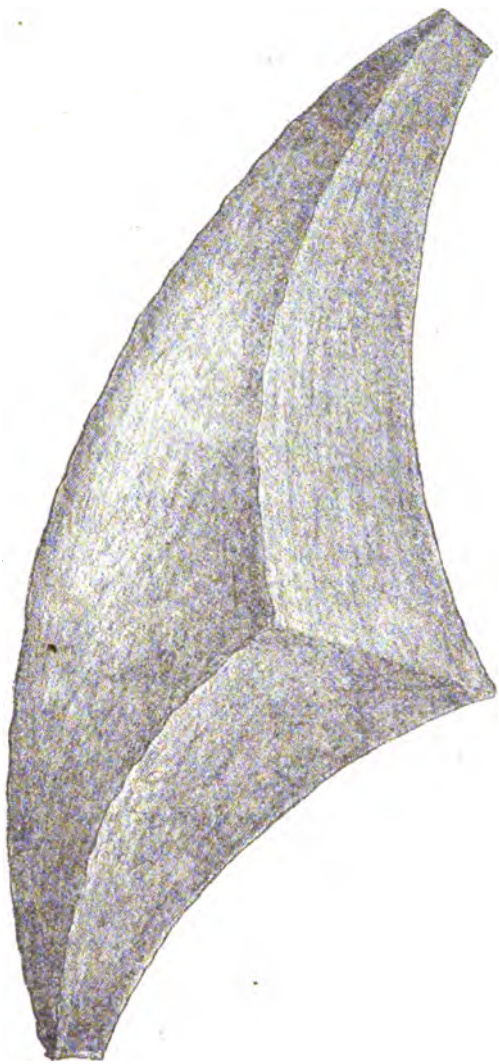


PLATE 29.

perforate the plate, but to strain, loosen, dislocate, and shake off the armor and break the fastenings.* The bolt, therefore, not only has to

*From the earliest period of experiments trouble had been experienced with fastenings. The French were the first to modify the evil, and their first attempt at modification was such a success that their new pattern armor-bolt was retained practically unaltered until comparatively lately. By the introduction of the Schneider bolt this part of the armor seems to have well-nigh reached perfection. (Very.)

hold the plate on the side of the fort or ship, but to resist vibration and prevent buckling. The best practice is to insert the screw-bolts into the rear of the plate without coming to the face, and in order to assist the plate in holding together till the shot is broken, and also that the shattered fragments may not fall, as many bolts as possible are desirable, provided they do not weaken the plate by penetrating too near the outer surface. Compound armor is at a disadvantage here over steel, as the back of the plate being laminated from rolling and not homogeneous, the bolt must be inserted farther to obtain sufficient hold. The number of bolts in a compound plate is therefore less than in a steel one, though the bolts are of larger diameter. Creusot bolts are used by the French Government entirely for both compound and steel armor.

Regarding the efficiency of compound armor as manufactured on the Ellis and Wilson systems, John Brown & Co. state that "*they* are convinced that steel armor does not possess any advantage over the compound, as, although they could readily make both, they still adhere to the compound, and no other is used by the British Government."

On the other hand, it must be remembered that in all the latest competitive armor-plate experiments the all-steel (Schneider) plate has been the victor; and although the British Admiralty were opposed to the verdict of the Italian experimental committee on the Spezia trials, they have presented no practical reasons to discredit it, nor does it appear that they have accepted the recommendations recently made to them to acquire a certain number of Schneider steel plates, if possible, and to have some competitive trials of their own. The Admiralty, I believe, have requested Mr. Schneider to furnish a few plates for the test of projectiles, but it is scarcely to be expected that Creusot will be willing to send its material for the investigation and information of the English manufacturers unless the English Government will make a contract for the armor for one or more ships.

The following opinion of Admiral Simpson, United States Navy, who was president of the Gun Foundry Board and president of the Naval Advisory Board, and who has given a long life to the study of ordnance questions; and that of an English artillerist who has recently inspected the productions of the different manufacturers and the results of the most important experiments, are pertinent and instructive:

My own judgment favors the steel plate. I think it more in the course of advanced ideas, and I am content with the results it has achieved in experiments; and the more experience we have in the manufacture, the more will we approach perfection in results.

I am aware that at Terre Noire, in France, it is claimed that a good steel armor plate can be cast which needs no forging, and I am under the impression that the same idea obtains at one of our own large steel establishments, but I have no confidence in such material, and I think that the first shot from a modern gun would dispel the illusion of those who entertain the idea. I accept as a fact that for the manufacture of steel armor plates there is required a heavy forging plant, and if we possess such facilities for forging our ingots for cannon, we have secured apparatus that will be equally serviceable for treating armor plates.*

The cost of a complete plant for the manufacture of compound armor would probably be as great as that for the manufacture of all steel armor, including a 100-ton hammer, but if the Whitworth hydraulic press be substituted for the large hammer, there will be much economy in the adoption of steel armor.† (Simpson.)

The feeling among French officers is very general in favor of steel armor. The compound plates manufactured in France are equal to those made in Sheffield. Comparing the test plates at Gâvre, the steel plates were superior to the French compound; and the targets used for the last Spezia experiments show that the steel plate was much superior to the English. (English Artillerist.)

*Extract from paper read before Washington branch of Naval Institute, December 4, 1885.

†Extract from circular letter, Navy Department, July 8, 1884.

DEVELOPMENT OF ARMOR.

For very interesting history of the development of armor, I take pleasure in again calling your attention to the publications mentioned in the early part of this paper.

Early in the history of wrought-iron armor it was found that a solid plate was some 33 per cent. stronger than a laminated one of the same thickness composed of 1-inch plates; but when solid armor attained a thickness of 12 inches the limit of guaranteed regularity of manufacture was reached, and experiments were made with several thicknesses of heavy plates. The results obtained were better than where the plates were thin, but a practical difficulty was encountered in the enormous cost of fitting the plates accurately to each other (which is very essential), and the utter impossibility of doing so when the plates were curved. Resort was therefore had to the sandwich system (interposing layers of wood between heavy plates). This was found fairly satisfactory for forts, but not for ships, where weight and space are such prominent factors. The experiments at Spezia in 1876 having proved that hammered steel Creusot armor was better than wrought iron, either solid or sandwiched, the latter has been gradually given up for ship armor and must soon give way to steel for forts.

Cast-steel armor (unworked) was tried by several firms, but it always broke up under fire, and was quickly abandoned.

Compound armor had been more or less experimented with for many years, but owing to the difficulty of securing uniformity in its manufacture, and the fact that wrought iron was still ahead of the development of artillery, we hear little of it until after 1876, when the success of French steel over iron caused the manufacture of compound armor to be rapidly developed in England, where the Government has made large use of it.

In reply to the claims that the Gâvre (French) trials of 1880, the Ochta (Russian) experiments of 1882, and the Amager (Danish) tests of 1884, proved the superiority of compound armor, an excellent answer is found in the following statement of Admiral Simpson:*

In 1880, a Cammell and Schneider plate were tested at Gâvre by the French Government, with a view to providing armor of the most perfect type for new armored vessels. The decision was in favor of the compound plate, but the report laid great stress on the possibilities of the development of steel, and in order to aid the Creusot works, a contract was made with Mr. Schneider for side armor for one of the ships.

When the selected armor plates were subsequently tested for reception, the steel plate proved to be superior to the compound plate.

In 1882, the Russian Government carried on a competitive trial between the Cammell and Schneider plates, at Ochta, near St. Petersburg. The result was decidedly in favor of the compound plate; but it was evident that the steel plate was not a fair sample of the manufacture, as its brittleness was apparent in its breaking up into several pieces.

In November, 1882, very famous trials were carried on at Spezia by the Italian Government, in which the 100-ton gun was used against the plates. The contesting firms were Brown, Cammell, and Schneider. Each submitted a test plate of 10 feet 10 inches in length by 8 feet 7 inches wide by 18.9 inches thick. These plates were fired at with a projectile weighing 2,000 pounds, a charge of powder of 328 pounds, and a stricking energy per inch of shot of 372 foot-tons. At the second round the Brown plate was split into six pieces, all of which except one were thrown from the target.

At the second round the Cammell plate was smashed and knocked completely off the target.

At the third round a portion of the center of the Schneider plate was broken out, and the upper right quarter was displaced.

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*Extract from circular letter, Navy Department, July 8, 1884.

In this competition the steel plate had the decided advantage, having withstood the effect of the second round without having its capacity of protection destroyed.

Competitive trials have lately been made by the Danish Government on the island of Amager, a suburb of Copenhagen, where a firing ground is established. The competitors on this occasion were four in number, Schneider, Brown, Cammell, and Marrel Frères, the latter submitting a compound plate manufactured under the Wilson patent, as in the case of the Cammell plate. The plates approximated to 9 inches in thickness, and were 4 feet 11 inches long by 6 feet 6 inches in width. The plates were bolted to a 9-inch oak backing, with skin plating and strengthening plates, and stiffened by angle irons, and braced in rear by heavy oak balks.

The guns used were a 15 cent. Krupp and a 10-inch Armstrong muzzle-loader, using, respectively, a charge of 43 pounds, with a projectile of 112 pounds, and a charge of 69 pounds, with a projectile of 402 pounds. One shot was fired at each plate from the 15 cent. gun, the result being much the same in all cases so far as the shot was concerned, as it broke up, leaving the head sticking in the plates. The targets were all more or less cracked by this gun, the order of merit being: No. 1, Brown; No. 2, Cammell; No. 3, Schneider; No. 4, Marrel.

The first rounds from the 10-inch gun broke off the left half of the Schneider plate, and passed clear through the other plates, the order of merit being: No. 1, Brown; No. 2, Cammell; No. 3, Marrel; No. 4, Schneider. The failure of the Schneider plate was evidently due to brittleness.

Reviewing the competitive trials cited above, we may safely conclude that the want of consistency in the results of the trials is not due to any want of uniformity in the compound armor. This manufacture has reached a high point of perfection, and the plates are produced with certainty as to their characteristics.

Such imperfections as they exhibit are due to the system of manufacture, not to the manipulation of separate plates, all of which exhibit a very uniform resistance to shot.

This has not been shown to be the case with all steel-plates. The cases cited above show some instances in which steel was superior and then again inferior to the compound armor, showing a want of uniformity in the results of the manufacture. The failures are always due to brittleness, but when this element is successfully suppressed the comparison is in favor of the steel plate. It would seem from this that the actual superiority of material rests with the steel, but that the problem of uniformity in manufacture is yet to be solved.

The question is a difficult one. The hardness of the steel is needed for the surface, but if this characteristic be continued through the whole mass, brittleness will ensue; the effort must be made to combine a hard surface with a softer material behind it, but this must be achieved in one homogeneous mass. The development of this work is steadily progressing at Le Creusot, and the action of the French Government in ordering steel armor for four new ships indicates its confidence in the latest results.

Harder faces have been made without increasing the vulnerable cracking, and Whitworth has repeated his successes, combining tenacity with surface-hardness.

The following comparisons of the tests of the plates manufactured by Schneider in 1883 for the "Furieux" and those for the "Amiral Baudin" in 1884 will show the great progress that has been achieved at Creusot, the result of the additional experience and the improvements in details that have insured uniformity and precision.

TESTS OF ARMOR PLATES FOR THE FURIEUX.

The plate tested July 13, 1883, at the French proving-ground at Gâvre was manufactured at Le Creusot in the usual manner, and was a tapered plate for the starboard side of the belt. It was 9 feet 10 inches long, 7 feet 7 inches wide, from 16 to 18 inches thick, and weighed 23 tons 9 cwt. It was secured by 20 bolts, according to the Schneider system, to a wooden target of the form required by the Gâvre committee. Three shots were fired from a 32-centimeter (12.6-inch), model 1870, navy breech-loading rifle at the apexes of an equilateral triangle, whose base was horizontal and 31.5 inches long.

The projectiles were chilled shot, weighing 761 pounds. The first and second shots, Plates 30 and 31, struck the plates at points 16.7 inches

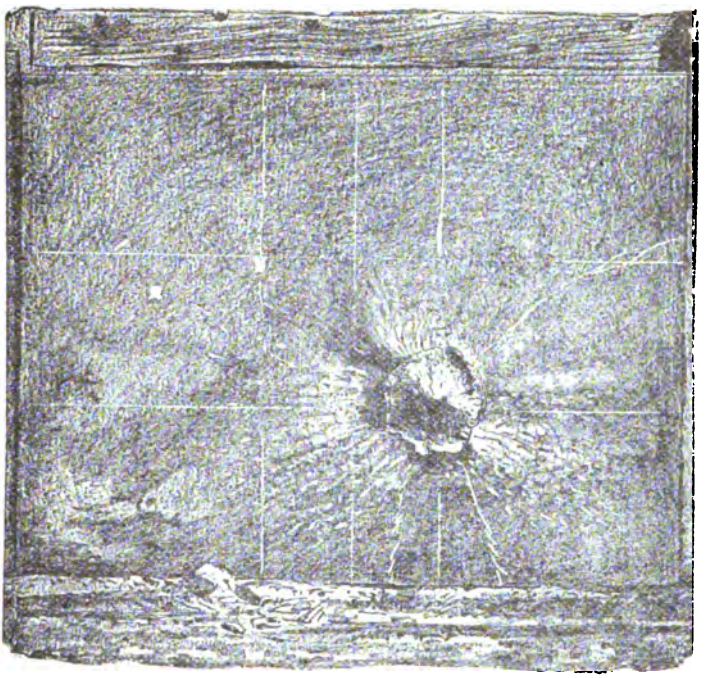

PLATE 30.

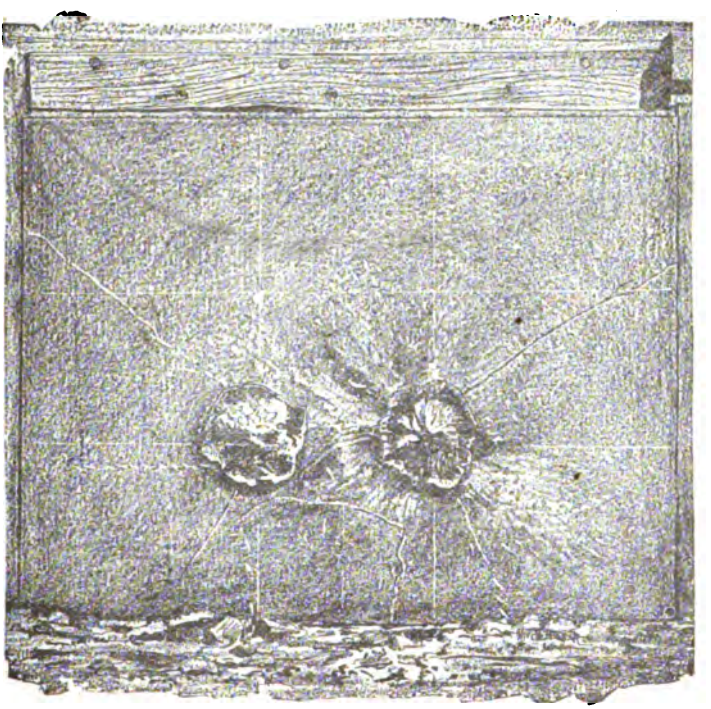

PLATE 31.

thick with a velocity of 1,416 feet per second. The third shot, Plate 32, struck the plate at a point 17.3 inches thick with a velocity of 1,452 feet per second. The projectiles were broken up, all the bolts remained in-

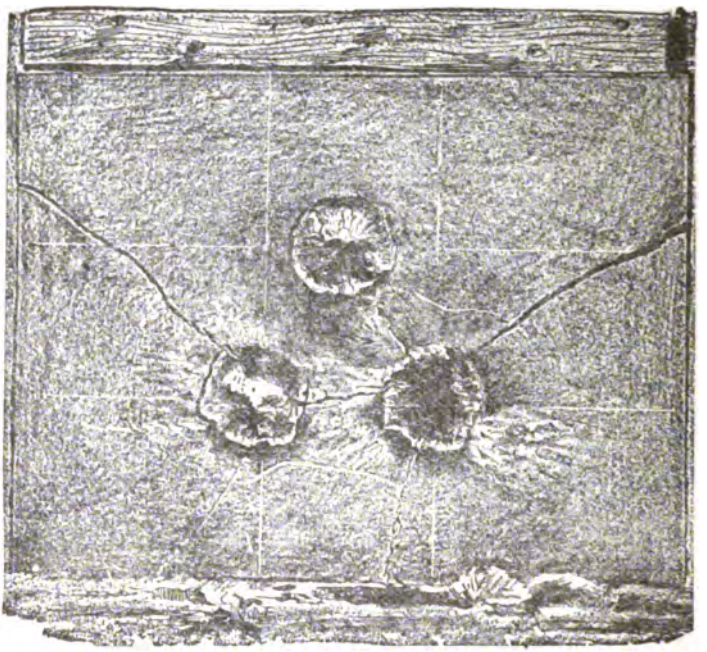

PLATE 32.

tact, no portion of the plate fell from the backing, and the tests, as proposed, were more than met.

TEST OF ARMOR PLATES FOR THE "AMIRAL BAUDIN."

The plate tested March 7, 1884, was tried at the same place, with the same gun and under the same calculated conditions. It was manufactured at Le Creusot in the usual manner, and was a tapered plate for the starboard side of the belt. It was 12 feet 9 inches long, 8 feet 2 inches wide, from 18 to 20 inches thick, and weighed 35 tons 9 cwt.

The first and second shots, plates 33 and 34, struck the plate at points 18.5 inches thick, with a velocity of 1,518 feet per second. The third shot, plate 35, struck the plate at a point 19.8 inches thick, with a velocity of 1,593 feet per second.

This plate was superior to the "Furieux" plate, as a comparison of the cuts will readily discover, and is an example of the great progress that is going on at Creusot in the manufacture of solid steel armor. The slight damage done this plate demonstrates the wonderful power of resistance, tenacity, homogeneity, and uniformity that characterize the latest productions of the Creusot works.

Descriptions of the latest competitive trials of compound and steel armor-plates will be found on pages 24 and 25 of the appendix.

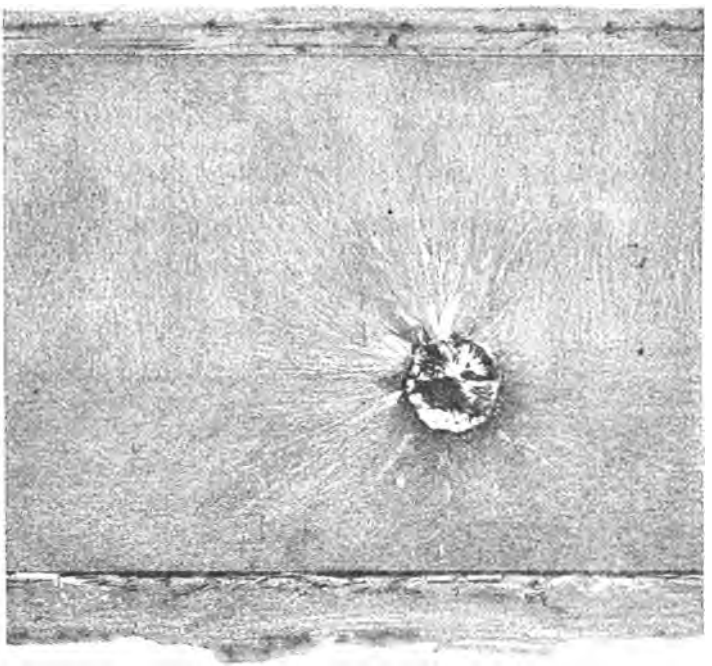

PLATE 33.

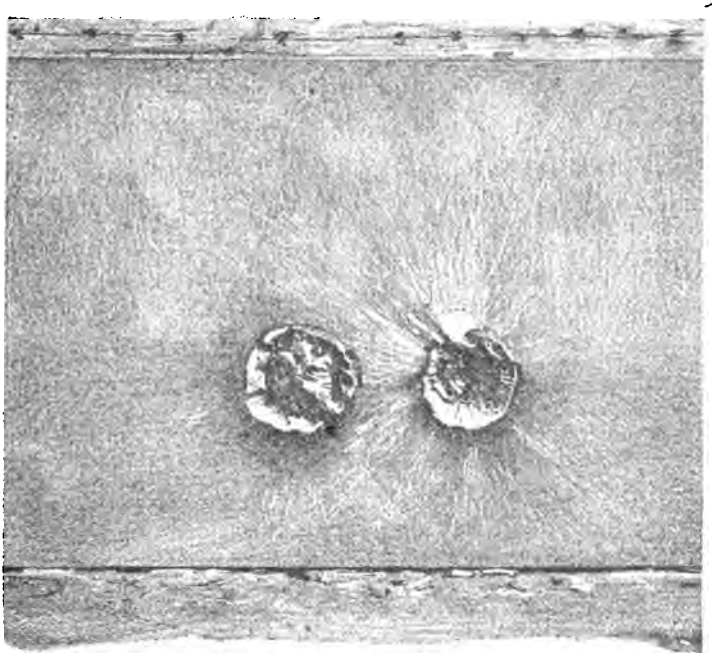

PLATE 34.

A remarkable and most valuable feature of the trial was that, after receiving the shot from the 100-ton gun, the Schneider plate was so hot that for several hours it could not be touched within two feet of the hole made by the shot, while in the compound plates the traces of heat were scarcely perceptible.

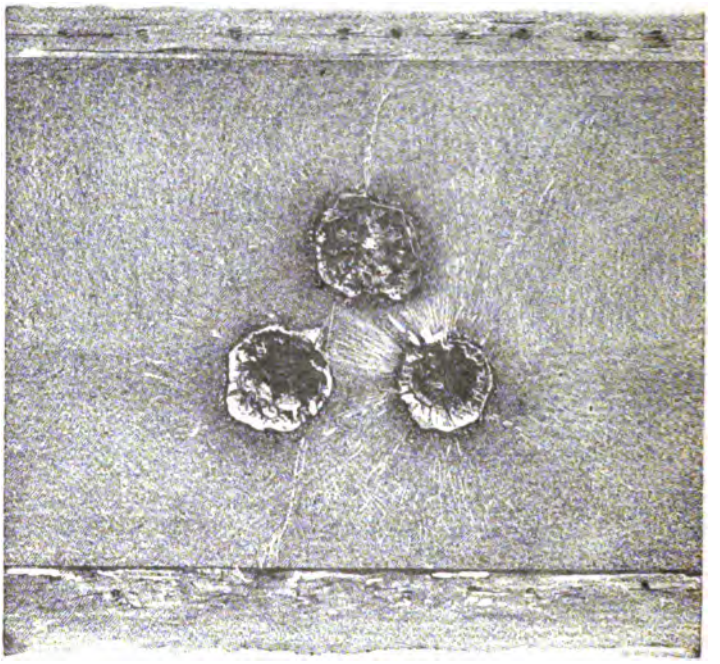

PLATE 35.

The importance that Lieutenant Weyl has given this phenomenon should be most carefully considered, for it proves incontestably that the Schneider plate not only absorbed much of the force of the shot in breaking it up, but had received an immense quantity of heat, with which the projectile had parted in entering the plate. This is of vital concern, for if the heat thus generated by impact on the *steel* plate will cause the explosion of the shell-charge prematurely, before reaching the interior of the ship, the efficiency of the plate is greatly increased, and Weyl has rendered a most excellent service in discovering another valuable property of the solid steel plate.

The contract for the Lepanto's armor was given to Schneider & Co.

In estimating the efficiency of armor it must be remembered that the acceptance tests are in many cases less severe than the competitive ones, and that the backing and armor fastenings* have such an immense influence upon the results that great care should be taken to look to those competitive trials which have been conducted with the strictest equality of conditions. The scientific exactness with which the Italian experiments have been made entitle the results obtained at

*The resisting power of the armor, as determined by the qualities of the metal plates, the disposition of the backing, and the distribution and strength of the fastenings. (Very.)

Spezia to be accepted as of the highest technical value. This cannot be said of the Danish experiments at Amager in 1884; the lottery of drawing the lucky position where the plate could be properly attached to the backing completely destroyed the comparative value of the trials. Further, the plates were only of medium thickness. As a result, however, a contract was awarded an English manufacturer; repeated reception tests under this contract, in 1885, I understand, were unsatisfactory.

In Italy the results have been so decisive, and the Schneider steel-plate has shown itself so far superior to the compound plates of the best makers, that the Italian Government has definitely committed itself to the exclusive use of Schneider steel by establishing works at Terni, near Rome, for its manufacture and further development.

In regard to future development, I am not alone in the belief that the progress is limited to steel. Whether the best steel plate will be compounded mechanically—and there are those who believe they have devised the means—or whether the Schneider hard front and soft back will reach the highest development by the methods he now employs, the future must decide; but the great cost of compound armor, and of sandwiching and accurately fitting wrought iron, added to their inferior resisting power and greater weight and space occupied, clearly demonstrate that for economic as well as military reasons *steel* is the best material for the armor of ships and fortifications.

STATISTICS.

Outside of England compound armor is used on 11 * French, 2 Russian, 2 Brazilian 2 Chinese, 1 Italian, 1 Danish, and 1 United States ("Miantonomoh") vessels. On the Continent, however, opinion is more divided than in England, and Schneider & Co. have furnished plates for 7 † French, 1 Danish, 1 Swedish, 1 Spanish, and 4 Italian vessels; in all, including test plates, more than 20,000 tons.‡ The contracts for the armor of the French ironclads Neptune (10,500 tons), Brennus (9,780 tons), and Charles Martel (9,780 tons) have not yet been made.

The thickest side armor afloat to-day is that on the English line-of-battle ship Inflexible, but it is of wrought iron and sandwiched. It consists of a 12-inch plate, then 12 inches of teak, then another 12-inch plate, then 6 inches of teak strengthened by angle-iron girders, and lastly an inner skin of two 1-inch iron plates.

The thickest solid side armor afloat is that of the two Italian line-of-battle ships Duilio and Dandolo, which consists of 22-inch solid plates of Schneider steel. It has greater power of resistance than the armor of the Inflexible.

The thickest solid armor that has passed the reception tests and is about to be floated is 22-inch Schneider steel for the two French line-of-battle ships Amiral Baudin and Formidable. It is superior to that of the Duilio and Dandolo, the steel being harder and tougher.

There are 198 armor-clad vessels in the world available for offensive operations against the United States, and 42 more are building, making a total of 240. Of these, 194 are plated with wrought iron, 19 with all compound armor, 12 with compound and wrought iron, 10 with all steel, 4 with steel and wrought iron, and 1 with steel and compound armor. Only 8 of the 42 now building have all wrought-iron armor, 6 of these being in Russia. Only 6 of the 240 vessels are under 2,000 tons' displacement; 209 of the 240 are over 3,000 tons.

England owns 70 armor-clads, of which 13 are building. France owns 50, of which 12 are building. Russia owns 24, of which 6 are building. Italy owns 19, of which 5 are building. Turkey owns 15. Germany owns 14. Austria owns 13, of which 3 are

* Six of these gunboats.

† Two of these gunboats.

‡ In comparing the amount of steel and compound armor furnished the French navy, it must not be forgotten that there are three firms in France manufacturing the latter, and that Creusot alone has furnished nearly as much as these other firms together.

building. Denmark owns 7, of which one is building. Holland owns 7. Spain owns 6, of which 1 is building; Brazil 6, of which 1 is building. Japan owns 3, Chili owns 3, China owns 3.

Besides these vessels, there are in Europe a large number of gunboats, monitors, and other vessels for coast defense, and an immense number of unarmored cruisers.

The United States has ready for service but 6 monitors of 2,100, and 8 of 1,875 tons displacement. These monitors are twenty years old, their guns are obsolete, their armor thin, and their power of offense or defense is insignificant. Besides these there are four monitors of over 3,800 tons each, and one (Puritan) of over 6,000 tons, in various stages of construction. The Miantonomoh, at the New York navy-yard, has hull and engines complete, and is being supplied with armor and guns. The Puritan, Amphitrite, and Terror are at private ship-yards; they have the hull and engines practically complete, and are ready for their armor and guns. The Monadnock, at San Francisco, has the hull complete, but requires engines, armor, and guns. These four monitors will require together about 3,000 tons of armor.

The 5 large monitors, if armed with 10-inch high-power steel breech-loading rifles, will make good fighting ships, and will be efficient for coast defense and for service in the West Indies or at the Isthmus of Panama; and if armored with *steel* plates instead of iron (for which they were designed), they will have a very much superior power of resistance with the same displacement.

The coast-defense fortifications of the United States are considered by all authorities to be about worthless; we have no torpedo-boats nor automatic torpedoes; and submarine mines and electrically controlled torpedoes can be easily taken up unless protected by guns and automatic torpedoes; yet, from the estimates of Lieutenant Griffen,* United States Army, there is now exposed to the fire of an enemy on our coast, in eleven cities, nearly five thousand millions of dollars of destructible property.

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* "Our Sea-Coast Defenses," 1885. G. P. Putnam's Sons.

PAPER

ON THE

BESSEMER ORES AND STEEL WORKS OF THE UNITED STATES

WITH REFERENCE TO

THE MANUFACTURE OF HEAVY GUNS AND ARMOR PLATES.

[Prepared for the use of the Select Committee of the United States Senate on Ordnance and War Ships. By J. W. Powell, Director of the United States Geological Survey. With paper by Albert Williams, jr., chief of the Division of Mining Statistics and Technology.]

STATEMENT OF MR. J. W. POWELL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, November 3, 1884.

To the Select Committee of the United States Senate on Ordnance and War Ships:

GENTLEMEN: I have the honor to acknowledge the receipt of your letter of the 14th of July, requesting "information of an exact character as to the ores that will be useful in steel-production, and much other valuable data in relation to this important resource of military power."

On the receipt of your request, attention was immediately given to the subject-matter of your inquiries, and the most thorough study of the matter has been made that the short time would permit.

There are three principal metallurgic methods of producing steel in vogue in the United States, namely, by the Bessemer, Crucible, and Open-hearth processes. The following exhibits the production of steel in the United States during the year 1883 by the principal and minor methods:

	Short tons (2,000 pounds).
Bessemer (acid)	1,654,627
Open-hearth	133,679
Crucible	80,455
All other steel	5,598
Total*	1,874,359

In the paper appended, Mr. Williams, the statistician of the Geological Survey, has summarized such information as we possess, relative to the quantity of Bessemer ore mined in the United States and its distribution throughout the country. From the facts presented it will be seen that we possess great quantities of ore suitable to the ordinary acid process of making Bessemer steel, and that they are ample for all probable, or even possible, demands for an indefinite time to come.

The Gilchrist-Thomas, or basic Bessemer process, has not been prosecuted in this country, and this leaves us without the experimental data which are indispensable to an opinion concerning the extent and distribution of ores suitable to it. But it may be remarked that highly phosphorized ores are adapted to this basic process, and such ores are abundant in many localities, and nowhere more so than in the coal regions of the United States; while in respect to other ingredients the constitution of the pig-irons which may be smelted from them can ordinarily be regulated by the smelter at will by his management of the blast-furnace. It thus appears that a cheap, convenient, and practically unlimited supply of ore, suitable to the Bessemer basic process, may be confidently anticipated whenever any important demand shall arise.

With reference to ores suitable to the production of steel by the Open-hearth processes, it may be remarked that the problem presents even less difficulty than with reference to the Bessemer processes. No method

* Total for 1884, 1,736,985 short tons. ("Mineral Resources," p. 250. A. Williams, jr.)

of smelting iron lays the producer under such stringent and narrow restrictions, relatively to the chemical constitution of the ores he must produce, as the Bessemer acid process. Other methods of ore-production usually permit the smelter to exercise a somewhat greater latitude in his choice of ores. It will thus be seen that the ores available for the Bessemer process are equally available for the Open-hearth and Crucible processes. At our present state of knowledge it seems probable that the Open-hearth processes are the best adapted for the production of steel to be used for heavy guns and armor plate; but, whatever process may be selected for this purpose, the known bodies of ore are ample for the production of any quantities that may be desired, and it is highly probable that many other bodies of ore known to exist, will, when tested, prove to be equally valuable for the production of steel.

There are certain important lines of investigation suggested in relation to this matter which I should have been pleased to undertake, but the work in these fields could not be prosecuted without some expenditure of money, and additional time would have been necessary. One of the most important of these relates to bodies of ore discovered throughout the United States during the past four years, and reported as Bessemer ores. A large number of these exist in the Southern Apalachian region and in the far west. To determine to what extent these claims are valid, it would have been necessary to sample the various bodies of ore and have them carefully analyzed.

In considering the facilities for manufacturing large masses of steel, the subject presents more difficulty. The castings required for heavy ordnance and armor far exceed in size those called for in other constructions, so that no demand has arisen for machinery capable of working such masses. Nor does it seem probable that at any time in the near future will such a demand arise, except for the construction of guns and defensive plates. Of these, the Government is the sole consumer, and should the necessary machinery be constructed for their production, its sole use would probably be in the making of war material for the Government.

It is probable that large Open-hearth furnaces, adequate to the casting of heavy ingots, could be added to several of the existing steel foundries of this country at an expense which might not seem very formidable to their proprietors, and that machinery capable of rolling the hoops used in nearly all modern built-up guns, could in like manner be provided at no very serious cost. But it does not seem probable that the very costly plant for forging and manufacturing guns and armor plates would be undertaken by private capital without such assistance from the Government as would be equivalent to a guaranty of the entire principal and interest invested.

In view of the above considerations it would seem to be wiser for the Government to build and operate its own factory for forging and machining its guns and armor. If by so doing, the Government were competing with private institutions, well founded objections might be raised, but this case is peculiarly exceptional, in that no possible competition could arise between national and private factories, as the work to be done differs altogether from that prosecuted for industrial purposes. If the articles required were currently produced by various manufactories, and currently bought and sold in the market, or if they were of such a nature that numerous existing workshops could, with moderate changes in their plants, easily furnish them, and the producers could compete with one another for contracts to supply them, without calling upon the Government for any special subvention, the Government might then

be regarded as a competitor of the private manufactories, should it proceed to build and operate its own workshops. But in the manufacturing of heavy ordnance and armor, the plant for producing them would be created for the wants of the Government alone, and would be employed exclusively in its service, and competition would be impossible. Should the Government subsidize a manufacturing establishment to such an extent as to enable it to do the work necessary for the production of heavy ordnance and armor, the relations thus established would in the end be embarrassing. Having once held out inducements for the creation of such an establishment, the Government would be compelled in equity either to keep it employed or else indemnify it for idleness, and thus it would create a fruitful source of claims for relief against itself. If, on the other hand, the Government were to build and operate its own factories, it would be under no duress beyond its own wants in making appropriations for them, and would have only its own interests to consider.

But the manufacturing of steel ingots presents a different problem. There are several establishments already in existence which could easily build larger furnaces and casting-pits quite adequate to this purpose. But the requirements of gun steel, in respect to the physical and mechanical properties of the metal, are exacting, and it will be more difficult to obtain the necessary skill and experience than the necessary casting-plant, and whether it would be better for the Government to establish furnaces of its own or depend upon private furnaces, I do not feel prepared to express an opinion.

I am, with respect, your obedient servant,

J. W. POWELL.

STATISTICS AND COMMENTS BY ALBERT WILLIAMS, JR.

BESSEMER ORES.

PRODUCTION OF BESSEMER ORE IN THE UNITED STATES IN THE CENSUS YEAR.

The mining statistics of the Tenth Census were collected and discussed by officers of the Geological Survey. The division in charge of statistics of the non-precious metals made an attempt to segregate, statistically, the ores suitable for making Bessemer steel from those which were not. The Bessemer ores mined in the United States in the year ending May 31, 1880, were estimated at 2,113,461 short tons, the total iron ore product for that year being 7,974,706 short tons. It should be observed that the ores designated as "Bessemer" were not necessarily those actually worked for Bessemer metal, but were merely such ores as came within the standard of purity (as regards phosphorus contents) arbitrarily assumed for the purpose of classification. The definition adopted is explained in the following extract from a letter (dated July 28, 1884) from Mr. Bayard S. Putnam, who was Professor Pumpelly's assistant in the census work:

All ore in which the iron-phosphorus ratio does not exceed *one-tenth of one per cent.* has been taken as Bessemer ore. This upon the assumption, first, that pig-iron must not contain more than one-tenth of 1 per cent. of phosphorus to be adapted to the manufacture of Bessemer steel; and, second, that all the phosphorus in an ore enters the pig. Perhaps neither of these assumptions is strictly true. It is certain that considerable ore with a phosphorus-iron ratio higher than 00.10 per cent. is used, *mixed*

with ores practically free from phosphorus, to make Bessemer pig; and doubtless mixtures of pig-iron with varying percentages of phosphorus are also used in the converter. But it was necessary to draw the line somewhere, and, all things considered, the limit adopted seems to be the best. It will be perceived from the above, that only such ore as would make Bessemer pig when smelted *alone* (that is, without mixture with other ores) is counted as Bessemer ore in the table. Another criticism which might, perhaps, be made is that the percentage of phosphorus should be divided, *not* by the per cent. of iron, but by, say, 105 per cent. of the percentage of iron, so as to make allowance for the carbon, silicon, etc., in the pig.

$$\left[\frac{\text{Per cent. P in ore}}{\text{Per cent. Fe in ore} \times \frac{1}{100}}\right] = \%\,\text{P in pig.}$$

Doubtless this would have given a close approximation, theoretically; but, practically, it would not have altered the figures appreciably.

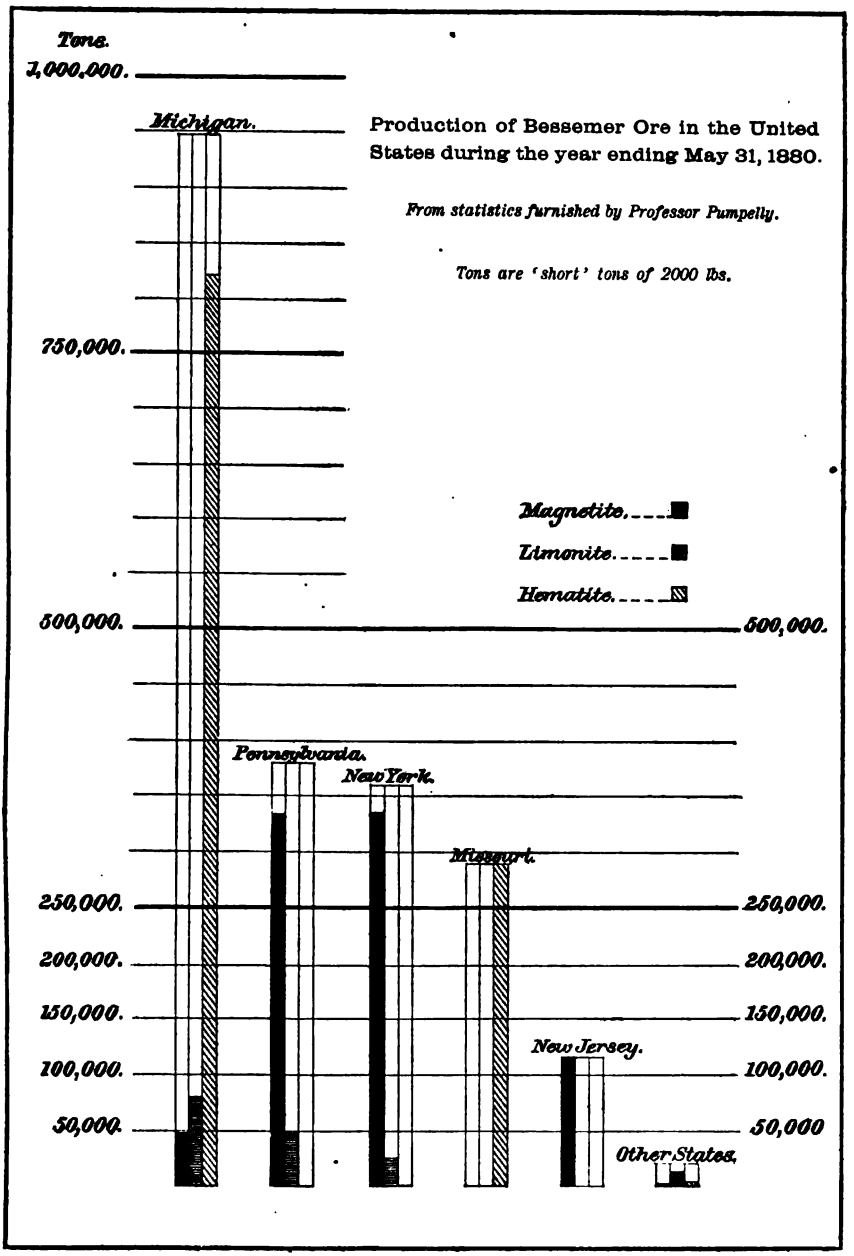
In regard to the samples and analyses on which the classification is based, the sampling of the iron mines was very carefully done under Professor Pumpelly's direction, and the analyses represent very closely the "run of mine" at the time the samples were taken. Some analyses were made of *specimens*, to throw light upon the distribution of phosphorus in certain ores, but in such cases analyses were also made of *samples* of ore from the same deposits. The Michigan ore samples consisted not only of stock-pile and stope samples at the mines, but also samples from large stock-piles at Cleveland, Ohio. The samples consisted of small chips, about the size of hickory nuts, and weighed from seven to forty pounds each. In many of the samples there were several thousand chips. All the important mines in the country were sampled, and a sufficient number of samples were taken from the different limonite and fossil ore banks of the South to indicate the character of the belts. Owing to the exhaustion of the appropriation the analyses of the Pennsylvania samples, with the exception of those from Cornwall and some of the allied deposits of magnetite, were not made; and the data for the classification of these ores (with the exception of the magnetites) were obtained from the second geological survey of Pennsylvania. There will doubtless be some alteration in the figures representing this State. The magnetite is probably correctly stated, but there is considerable limonite *used* for Bessemer, and it is certainly probable that more than 50,000 tons of this ore is sufficiently free from phosphorus to come into the table. The classification was made with considerable care; at the same time it is, after all is said, but an approximation. But I believe it to be a close one.

The following table has been kindly furnished from the manuscript census report of Prof. Raphael Pumpelly on "Non-precious metal ore." In this table is included only such ore that, if *smelted alone*, would produce pig containing not more than one-tenth of one per cent. of phosphorus. It should be stated here, however, that ore with a higher iron-phosphorus ratio than 0.10 is used *in mixture* in the manufacture of Bessemer pig. Tons are short tons of 2,000 pounds:

Bessemer ore product in the year ending May 31, 1880, *by States and kinds.*

State.	Magnetite.	Hematite.	Limonite.	Total.	Per cent.
	Tons.	*Tons.*	*Tons.*	*Tons.*	
Maine	.....	.....	6,000	6,000	0.28
Michigan	47,300	821,234	80,055	948,589	44.88
Missouri	.....	287,980	.....	287,980	13.63
New Jersey	114,841	.....	.....	114,841	5.43
New York	336,016	.....	24,805	360,821	17.07
North Carolina	2,750	.....	112	2,862	0.14
Pennsylvania	331,350	.....	49,258	380,608	18.01
Tennessee	.....	.....	5,600	5,600	0.27
Virginia	.....	3,360	2,800	6,160	0.29
Total	832,257	1,112,574	168,630	2,113,461	.....
Per cent	39.38	52.65	7.97	100.00	100.00

The accompanying diagram, which has been prepared from the census figures, illustrates graphically the sources of Bessemer ore and the relative quantities mined in that year of the three mineralogical types—magnetite, limonite, and hematite.


Tons.
1,000,000.
Michigan.
Production of Bessemer Ore in the United States during the year ending May 31, 1880.
From statistics furnished by Professor Pumpelly.
Tons are 'short' tons of 2000 lbs.
750,000.
Magnetite.
Limonite.
Hematite.
500,000.
500,000.
Pennsylvania.
New York.
Missouri.
250,000.
250,000.
200,000.
200,000.
150,000.
150,000.
New Jersey.
100,000.
100,000.
50,000.
50,000
Other States.

From these statistics it appears that, in the census year, Michigan yielded very nearly one-half of the total Bessemer ore product of the United States (948,000 short tons, as against a total of 2,113,000 short tons), and that of the Michigan output by far the greater part was hematite. The Michigan ores classed as Bessemer formed considerably over one-half of the total iron-ore output of the State in the census year, as may be seen by reference to a subsequent table. In point of quantity, Pennsylvania, New York, and Missouri stood on a par; the Bessemer ores of the two first named States being mainly magnetite, while those of Missouri were wholly hematite. The magnetite ores of New Jersey formed a considerable factor in the question of supplies.

As regards the mineralogical kinds of ore ranked as Bessemer in the preceding table, hematite takes the lead (1,112,000 tons), closely followed by magnetite (832,000 tons), while limonite (168,000 tons) forms only about a twelfth part of the total. The classification, however, is merely approximate. It is true that little reliance can be placed upon the mineralogical name given to an ore as a guide to its purity, some magnetites, for example, running quite high in phosphorus.

THE PRODUCTION OF BESSEMER ORES IN THE UNITED STATES IN 1883.

Replies from Mr. James M. Swank, secretary of the American Iron and Steel Association (August 9, 1884).

Q. The total iron-ore production of the United States in 1883 being estimated at about 9,000,000 long tons (of 2,240 pounds), of this how much, in your opinion, could be classed as Bessemer ore; not how much was used in making Bessemer steel, but how much might have been properly so used? Please distinguish between ore which could be used alone, and ore requiring to be mixed.—A. Fully 2,500,000 tons could have been used alone in the production of Bessemer pig-iron, and another 1,000,000 tons could have been used in mixture with pure ores.

Q. On what definition of "Bessemer" ore do you base this estimate?—A. The possession of a small percentage of phosphorus.

DOMESTIC SOURCES OF BESSEMER ORES.

Nearly the whole present domestic supply of Bessemer ores comes from the Lake Superior district in Michigan, the Champlain district of New York, and Missouri. In the latter State the sources are the Iron Mountain and Pilot Knob region. Besides these, there are the Tilly Foster mines, Putnam County, New York; the Hudson River mines, Columbia County, New York; the mines of Northern New Jersey; the Cornwall mines, near Lebanon, Pa.; the mines of the Colorado Coal and Iron Company, in Colorado; the Cranberry mines, in Western North Carolina, and various openings in Virginia.

Valuable deposits have already been discovered in the far West (see pages 145 to 148, "Mineral Resources of the United States"), notably in the Rocky Mountain region, though they have not yet been developed to any extent, and, with the exception of a few beds opened in Colorado, actual tests on a working scale are wanting. The distance from any but a restricted local market will always operate unfavorably against these western sources; and while in time Colorado, Wyoming, and Utah will undoubtedly become self-supporting as regards iron and steel manufactures, and their works will be to a certain extent protected by the heavy freights from competition of the Eastern furnaces, foundries,

and mills, it is evident that for the present purposes their capabilities have little significance. The same remark applies to the ore beds of the Pacific coast. To a tract of country at no great distance from the Eastern seaboard, we must look for our ore supplies. Even Michigan, Missouri, and Northern New York are at a great disadvantage in point of freights, when competing at centers so remote from their iron mines as, for example, Pittsburgh.

THE LAKE SUPERIOR DISTRICT.

The entire yield of all kinds of iron ore from the Lake Superior district has been reported by Mr. A. P. Swineford, the present State commissioner of mining statistics, as follows:

Calendar years.	Long tons.	Calendar years.	Long tons.
1856 and previous	86,319	1871	813,984
1857	25,646	1872	948,553
1858	22,876	1873	1,195,234
1859	68,832	1874	935,488
1860	114,401	1875	910,840
1861	114,258	1876	993,311
1862	124,169	1877	1,025,129
1863	203,055	1878	1,125,093
1864	247,059	1879	1,414,182
1865	193,758	1880	1,987,598
1866	296,713	1881	2,321,315
1867	465,504	1882	2,948,307
1868	510,522	1883	2,352,889
1869	639,097		
1870	859,507	Total	22,943,689

The quality of the Lake ores is excellent, the phosphorus and sulphur contents being very low; but the freights to the works in Western Pennsylvania, where the greater part of these ores are smelted, add greatly to their cost, and in localities near the seaboard they can hardly compete with foreign ores under existing conditions. The want of suitable fuel in the neighborhood of the Lake iron mines is severely felt. The Michigan charcoal iron industry is not at present of great importance. Smelting with charcoal, though producing fine pig, is an operation which is economically at a disadvantage as compared with smelting with coal and coke, while the latter fuels are steadily being used to better effect in point of quality of the product. Modern improvements in blast-furnace practice, and the use of mineral fuel nearly free from sulphur, have greatly changed the relations between charcoal iron and that made with coal or coke or mixed coal and coke.

THE CHAMPLAIN DISTRICT.

Mr. Swank has estimated the total iron-ore output of the Champlain district during the calendar year 1883 at 500,000 long tons. Mr. Frank S. Witherbee, of Port Henry, Essex County, New York, in response to an inquiry, writes (August 7) that of this amount 202,000 tons may be classed as ore suitable for the acid Bessemer process; defining such ore as that running below .08 per cent. phosphorus and .15 per cent. sulphur. These 202,000 tons were mined by the following-named companies:

	Tons.
Chateaugay Company, Plattsburg, N. Y. (estimated)	100,000
Crown Point Iron Company, Crown Point, N. Y. (estimated)	60,000
Port Henry Iron Company, Port Henry, N. Y.	16,000
Witherbees, Sherman & Co., Port Henry, N. Y.	11,000
Palmer Hill Company, Au Sable Forks, N. Y., and other mines (estimated)	15,000
	202,000

Mr. Witherbee states that if the basic process were adopted, the product of the Port Henry Company (of ore suitable for making Bessemer steel by the basic process) should be placed at 260,000 tons; that is, extending the definition to include all ores containing 1 per cent. phosphorus and below 5 per cent. silicon.

Mr. Witherbee writes:

The production of 1883 is hardly a fair criterion of the capacity of this region, as the Chateaugay Ore and Iron Company and Witherbees, Sherman & Co. have procured additional machinery and have developed new territory, which now enables them to deliver the ore cheaper, and also to greatly increase their output of strictly Bessemer ores. I have mentioned the cold-short ores of this region, as with the Thomas-Gilchrist basic process, now in use in Europe, I understand that they have been considered of value for steel plates and armor. The late Mr. A. L. Holley, of New York, and Mr. I. Lowthian Bell, of England, have both told me that they considered the rich magnetites of this region as the best ores in the world for that process, being high in phosphorus and low in silicon.

Mr. Witherbee makes the following replies to questions:

Q. Of the usual run-of-mine, what is the phosphorus contents?—A. Below .03 per cent.

Q. Sulphur contents?—A. None.

Q. Titanium contents?—A. None.

Q. What is the composition of the purest selected ore of the district, obtainable in sufficient quantity (an average analysis, if possible)?—A.

Metallic iron	68.24
Oxygen	26.01
Siliceous matter	4.32
Alumina	.28
Lime	.14
Phosphoric acid	.038
Water	.38
Undetermined	.592
Total	100.000

This ore is known as New Bed Pure, and is sold on a guarantee of 65 per cent. iron, &c. It is a mine recently acquired by Witherbees, Sherman & Co., Port Henry, N. Y., and is capable of producing 50,000 tons per annum.

Q. What is the present price of Champlain ores, at the mine, per long ton?—A. New Bed Pure ore, $4 at Port Henry; Chateaugay ore, $2.75 at Plattsburg; basic ores, $2.50 at Port Henry.

Q. Where and how were the shipments of 1883 smelted (whether mixed with other ores, for what grade of iron worked, whether converted or made into other steels than Bessemer, &c.)?—A. The ores were mixed with other ores and smelted for Bessemer pig at Bethlehem and Scranton, Pa., Franklin and Secaucus, N. J., Hudson, Fort Edward, Crown Point, and Plattsburg, N. Y. At the forges of the Chateaugay Company a large amount of ore was separated and worked up into steel billets, &c.

In this district (Champlain) 500,000 tons could easily be produced of strictly Bessemer ores, yielding alone 50 per cent. of iron and within the limits in phosphorus and sulphur. For the basic process, the supply of ores yielding 65 per cent. of iron and about 1 per cent. phosphorus is practically unlimited. The best soft steel made abroad for ships is, I understand, made by the basic process. These ores seem to be the cheapest raw material in this country, as they can be sold at tidewater for $3.50 per ton, with a guaranteed yield of 63 per cent. in the furnace.

REPLIES FROM MR. A. L. INMAN, PLATTSBURG, N. Y., AUGUST 19, 1884.

Q. Mr. Swank states the production of the Champlain district in 1883 at about 500,000 long tons. Of this, how much, in your opinion, was Bessemer ore, or ore suitable for steel-making?—A. I think Mr. Swank underestimates the amount of ore from the Champlain district for 1883. At all events there was raised from the Chateaugay and Crown Point mines in 1883, 280,000 tons, and in addition there was, I should say, 50,000 tons raised from Port Henry, Au Sable, and Verona, making a total of 330,000 tons of steel ores from Champlain district.

Q. What proportion of the shipment in 1883 was magnetite?—A. All magnetite.

Q. What is your definition of a "Bessemer" ore?—A. An ore comparatively low in sulphur, and that will produce a metal not exceeding .10 to .12 per cent. phosphorus.

Q. Of the usual run-of-mine, what is the phosphorus contents?—A. Chateaugay ore, .02 per cent; Crown Point ore, .023 per cent.

Q. Sulphur contents?—A. .04 per cent.

Q. Titanium contents?—A. Traces only.

Q. What is the composition of the purest selected ore of the district obtainable in sufficient quantity (an average analysis, if possible)?—A. Chateaugay ore, average sample of ore taken from seven openings upon the vein, near Lyon Mountain, New York, and which is believed to fairly represent the ore as shipped to market, contains—

Magnetic oxide of iron	70.592
Alumina	1.283
Lime	4.260
Magnesia	2.112
Manganese	Traces.
Silica	19.260
Phosphoric acid	0.031
Sulphur	0.088
Water	1.080

Also small quantities of carbonic acid, alkalies, and so forth, which we did not deem worth determination.

Metallic iron	51.118
Phosphorus	0.013

(Analyzed by Booth, Garrett & Blair.)

Crown Point ore—

Peroxide of iron	49.72
Protoxide of iron	20.62
Protoxide of manganese	0.21
Alumina	2.62
Lime	1.16
Magnesia	0.68
Silica	24.52
Phosphoric acid	0.06
Sulphur	0.02
Iron	50.84
Phosphorus	0.026

(Analyzed by A. S. Bertolet.)

Q. What is the present price of Champlain ores, per long ton?—A. Sold delivered on board cars, or vessels, at the lake, at an average price of about $3 per long ton.

Q. Where and how were the shipments of 1883 smelted (whether mixed with other ores, for what grade of iron worked, whether con-

verted or made into other steels than Bessemer, &c.)?—A. They are generally mixed with other ores, and in 1883 were smelted at Port Henry, Crown Point, Fort Edward, Troy, Albany, and Poughkeepsie, N. Y., and at Scranton and Bethlehem, Pa., for the production of Bessemer and a fine grade of mill iron. I think that 75,000 to 100,000 tons of steel ore, produced in this district, is manufactured by the Chateaugay Ore and Iron Company, the Crown Point Iron Company, and others, into billets and blooms (in the Catalan forges) for the production of steel plate and crucible steel, &c.

Q. In brief, what is your opinion as to the independence, or otherwise, of the United States as regards imports of Spanish or other ores; the capacity of the Champlain district; the purposes to which the ores of that district are best suited; whether the import of ore is metallurgically necessary or merely a question of economy, &c.?—A. In answer to this question I include in the Champlain district the Hudson River mines near Catskill, as they are practically in the same district, and the ore is accessible to all points reached by the Lake Champlain ores. The possible output of the Chateaugay, and also the Hudson River mines, with the present developments and those in progress, is, in my judgment, practically unlimited, and could be made commensurate with every eastern demand of the United States, or in markets accessible to the foreign ores of Europe or Cuba; and the mixture of these two ores, or a mixture of Chateaugay, Crown Point, and Hudson River ore would, in my judgment, make as good Bessemer as can be made from any ore, foreign or produced in the United States.

THE PENNSYLVANIA ORES.

Replies from Prof. Andrew S. McCreath, of the Second Geological Survey of Pennsylvania, Harrisburg, Pa. (*August* 7, 1884).

Q. Are strictly Bessemer ores mined in Pennsylvania?—A. There are no ores in Pennsylvania which could be depended upon to yield anything like a permanent or reliable supply for the manufacture of Bessemer pig-iron, to be made exclusively from native ores. Many of our ores are sufficiently low in phosphorus to be considered, generally speaking, Bessemer ores, and there are many others just outside of that limit, *per se*, but which could be used as a mixture for Bessemer pig-iron with ores practically free from phophorus. Were it not that Cornwall ore (Lebanon County) contains more or less copper, so that a pig-iron made from it alone could not be depended upon, as a regular supply, for Bessemer steel, without using other irons free from copper with it to bring the average down to a safe point, it would form our largest supply of low-phosphorus ore. The Dillsburg District (York County) yields considerable ore low enough in phosphorus to be considered Bessemer ore. In Lehigh, Berks, and Chester Counties there are small banks yielding ores low enough in phosphorus for Bessemer pig, but in no case do these form an appreciable amount of the ore used in our Bessemer pig-iron production. All of these are magnetites. In Centre, Blair, and Huntingdon Counties considerable limonite is mined and used in the manufacture of Bessemer pig, but only in conjunction with foreign or Lake Superior ores. We have no red hematite in Pennsylvania worth considering in connection with the production of Bessemer pig-iron. Practically speaking, therefore, Pennsylvania has no Bessemer ores which could be depended upon alone to supply the stock to our blast-furnaces now making Bessemer pig.

Q. What is your definition of a Bessemer ore?—A. On this practical basis, I would consider a Bessemer ore as one whose composition is such that it could be smelted *alone* to produce a quality of pig-iron that could be depended upon, in itself, to yield a uniform quality of Bessemer steel, showing neither red-shortness nor cold-shortness in the finished metal. This applies to a single ore; but a mixture of two or more ores might produce an iron suitable for Bessemer steel, which any one of the ores in the mixture might not do *per se*. On this basis we have considerable ore in Pennsylvania which might be classed as "ore suitable for Bessemer pig-iron;" but there is no single ore in quantity which would come in under the first definition.

Q. What are the mineralogical classes of Pennsylvania ores?—A. Chiefly magnetite in Eastern Pennsylvania; with limonite in middle or Western Pennsylvania, as already stated in my answer to a previous question.

Q. Are any of the Pennsylvania ores used in the production of Bessemer pig worked alone, or are they always smelted in mixture with other ores?—A. Mixed generally with imported ores at the eastern furnaces, and with lake ores at Pittsburgh and Johnstown, although occasionally there with foreign ores.

Q. Briefly, what progress is the basic-process making in Pennsylvania steel works?—A. At only one works in the United States (the Pennsylvania Steel Works, at Harrisburg) has the basic process been tried. An excellent quality of steel has been made; but thus far the cost of making the steel has been so great as not to render the system here a practical success as compared with the acid method.

Q. Would its success greatly extend the availability of American ores?—A. The practical success of the basic process, by which a uniform quality of steel can be made from high-phosphorus ores, will undoubtedly render available a large class of ores now but little used. It will also enable the large piles of mill-cinder, carrying from 1 to 1.50 per cent. of phosphorus, to be used in the blast-furnace without the usual objection to "cinder iron."

I have tried to answer these questions from a practical standpoint, and have not considered the usual definition of a Bessemer ore as one whose contents of iron and phosphorus are such that it will make pig-iron carrying not over one tenth of 1 per cent. of phosphorus.

THE IRON ORES OF NEW JERSEY.

From the following replies of Mr. I. P. Pardee, treasurer of the Secaucus Iron Company, of Stanhope, N. J. (August 23, 1884), it appears that the iron ores of this State are not very highly regarded by the producers of Bessemer pig—at least for smelting alone:

Q. Professor Cook states the production of iron ore in New Jersey during the year 1883 at 521,416 long tons. Of this, how much, in your opinion, was Bessemer ore (that is, ore suitable for making Bessemer pig, without mixture with other ores)?—A. I do not know of any ore now being mined in New Jersey that is suitable for the manufacture of Bessemer pig here without admixture with other ores.

Q. What is your definition of a Bessemer ore? Per cent. phosphorus; per cent. sulphur?—A. We do not buy any ore for making Bessemer pig-iron having more than .04 per cent. phosphorus or sulphur.

Q. Can you give a fair ideal analysis of the best New Jersey ore, obtainable in quantity?—A. The best ores of New Jersey are all too high in phosphorus for the manufacture of Bessemer iron. An average

analysis of the Dickerson ore, from probably the oldest-worked mine in the State, and one of the best ores (magnetite), is:

	Per cent.
Metallic iron	60 to 65
Phosphorus	0.371
Silica	5.848

The analysis was made by Mr. John M. Sherrerd, chemist of the Troy Steel Works.

Q. Present average price per ton of 2,240 pounds at mine of different kinds of New Jersey ores?—A. Magnetic ores containing 50 per cent. metallic iron can be bought now for from $2.50 to $2.75 per ton.

Q. Any further information?—A. The little ore that has been mined in New Jersey and used for Bessemer iron has never been used without admixture with foreign ores or ores from other States. The ore rich in iron is high in sulphur. There are two or three small veins in New Jersey of ore very low in phosphorus, running sometimes down to 0.014 per cent. phosphorus; but their ores are very lean, and the mines have been abandoned on account of the small percentage of iron.

The statistics of the output of New Jersey iron ore, as compiled by Prof. George H. Cook, are as follows:

Calendar years.	Long tons.	Calendar years.	Long tons.
1790	10,000	1873	665,000
1880	20,000	1874	525,000
1855	100,000	1875	380,000
1860	164,900	1878	402,674
1864	226,000	1879	488,026
1867	275,067	1880	745,000
1870	362,636	1881	737,052
1871	450,000	1882	882,762
1872	600,000	1883	521,416

WHAT IS A BESSEMER ORE?

Definitions of "Bessemer" ore, as accepted by Professor Pumpelly, Professor McCreath, and others, have already been quoted. The definitions in vogue in the United States refer exclusively to ore used in making pig which is converted into Bessemer steel by the common acid method, as the basic process has only been introduced experimentally in this country. An ore which will make pig suitable for the ordinary converter, and whose final product is good Bessemer metal, is taken as a type of steel ores. When the basic process shall have reached such a development in the United States as it already has abroad, a field will be opened for ores higher in phosphorus than those which are now marketable. The basic process is also applicable in the manufacture of open-hearth steel.

The following question being asked: "What is your definition of a 'Bessemer' ore (maximum percentage in ore of sulphur and phosphorus)?"—

Mr. Robert Forsyth, of the Spang Steel and Iron Company, of Pittsburgh, replies: "Strictly speaking, a 'Bessemer' ore is one which, with reasonably pure flux, will give a pig with not more than 0.10 per cent. phosphorus. If the ore holds 60 per cent. metallic iron, it should not exceed 0.05 per cent. in phosphorus, and with leaner ores still less would be allowable. The sulphur in an ore is *rarely* an obstacle to its use in the blast furnace, as by proper furnace management a great deal of sulphur can be removed. An ore holding 0.50 per cent. sulphur is not

necessarily unfit for steel making. The other impurities commonly found in iron ores, with the exception of titanium, are not important."

Mr. Alexander H. Sherrerd, chemist of the Lackawanna Iron and Coal Company, says: "The amount of sulphur in the ore depends so much upon the nature of the ore, and the working of the furnace using it, that it is almost impossible to give definite figures. The hurtful amount of phosphorus in steel made by the acid process, depends to a very great extent on the amount of carbon, silicon, and manganese with it in the metal. These elements have different degrees of hardness and deleterious power, which is only approximately understood, and which should be, and can be, carefully worked out by experiment. That is to say, when some of these elements are at their minimum others may be at their maximum, the steel remaining of the same quality."

Mr. S. T. Wellman, superintendent of the Otis Iron and Steel Company, of Cleveland, says: "For the acid process, ores, to make good Bessemer pig, should not contain more than 0.06 per cent. phosphorus and 0.03 per cent. sulphur."

Mr. John Birkinbine, of Philadelphia, Pa., gives the following definition: "Whatever amount of sulphur, phosphorus, &c., the steel works can use economically in mixing with the ores forming the base of the charge."

Mr. W. F. Mattes, of Scranton, says: "A precise definition cannot be given, as phosphorus and sulphur may vary according to combination with other elements. But for the purpose of a standard, our chemist has agreed upon the following for a first-class Bessemer ore: Phosphorus, .0008 per unit of metallic iron; sulphur, .005 per unit. In a 50 per cent. ore this will give: Phosphorus, .04 per cent.; sulphur, .25 per cent.

AMERICAN AND FOREIGN ORES.

The question being asked, "What is the present status of the United States in regard to independence of, or dependence upon, imports of foreign ore? Are the imports metallurgically necessary, or are they merely used for economic reasons?"—

Mr. James M. Swank, secretary of the American Iron and Steel Association, replies: "There is no scarcity of Bessemer ores in this country, the supply being limited only by the demand; but for economic reasons we annually import about one-fourth of our supply of ores required in the production of Bessemer pig iron."

"How do our best Michigan, Champlain, and New Jersey ores compare with Spanish or other imported?"

Mr. S. T. Wellman, superintendent of the Otis Iron and Steel Company, of Cleveland, replies: "They generally contain more phosphorus."

Mr. W. F. Mattes says: "Best Michigan, Champlain, and Hudson River ores compare favorably; New Jersey and Cornwall (Pa.), unfavorably; Virginia deposits, disappointing; North Carolina, undeveloped and transportation costly; Iron Mountain and Colorado, too remote."

Mr. E. S. Moffat says: "In my opinion the best Michigan and Champlain ores compare favorably with any of the imported ores."

Mr. Alexander H. Sherrerd says: "Very favorably."

Mr. John Birkinbine says: "Will probably average as good in quality, but our ores are often more refractory."

The gentlemen whose answers are here quoted (with the exception of Messrs. Swank and Birkinbine) are *consumers* of iron ores. Their opinions seem to differ considerably, but this is owing to the broad way in

which the question is put, and to the different standpoints from which it is viewed. Perhaps a fair statement of the case, and one which will reconcile the discrepancies of the foregoing opinions, would be: There are in the United States ores fully equal to the foreign ores which we import. As, however, the imported ores are the best of their class, they should be compared, not with the average run of what are considered good Bessemer ores, but with the best selected native ores; and when this view is taken it will be seen that the domestic ores compare favorably with the imported, class for class, and that there is no difficulty as to quantity. The high freights, resulting from the long distances of our best mines from the great metallurgical centers, prevent the consumer from exercising a free choice in the selection of ores, and in making a comparison between the domestic and the foreign ores he is bound to consider the economic side of the question. It seems to be a fact that those smelters who rely most, or altogether, upon the native ores have the best opinion of them. A good ore is a good ore, whether it comes from Spain, or from Michigan, or from the Champlain district; so far as quality alone is concerned, the question is merely one of analyses. But there is no disguising the fact that at some furnaces, under the existing tariff and the present ocean freights, a better foreign ore can be laid down than can be had from domestic sources at the same price. Ore brought at low rates of freight or as ballast, and carried a short distance from the port of entry, can readily compete with domestic ore carried long distances by rail, the duty being offset by the original cheaper cost of mining. This statement holds only for certain localities.

Krupp and many other foreign consumers procure large quantities of their ores from mines outside of their own countries, especially from those of Spain; in such cases the imports are necessary from metallurgical reasons. Our imports cannot fairly be thus explained.

THE IMPORTATION OF ORE AND SPIEGEL.

The question being asked, "Is the importation of ore and spiegel necessary from a metallurgical standpoint, or merely a question of economy?"

Mr. Robert Forsyth says: "The importation of ore is an economical, that of spiegel (at present) a metallurgical, necessity."

Mr. W. F. Mattes says: "Importation of ores is a question of economy merely. Importation of spiegel is a necessity at present."

Mr. E. S. Moffat says: "There is enough good ore in the United States to make all the steel that is needed; consequently, the importation of ore is not a metallurgical necessity. Excellent steel is made at Scranton, by the Lackawanna Iron and Coal Company, entirely from American ores. Some of the Eastern steel works are so located, however, that, as the duties now are, there is economy in using the foreign ores. At present it is probably necessary to import some spiegel."

Mr. Alexander H. Sherrerd says: "Neither. Not necessary nor economical, if very slight attention is given to the subject."

Mr. S. T. Wellman says: "Merely a question of economy."

Imports of iron ore.

Calendar years.	Long tons.	Values.
1881	782,887	$2,222,652
1882	589,655	1,640,564
1883	490,875	1,297,991

The imports were principally from Spain. It will be observed that the decline in 1883, as compared with the imports for 1881 and 1882, is greater proportionally than the set-back to the iron trade.

SPIEGELEISEN.

The question being asked, "How does American spiegel compare with imported?"—

Mr. Swank says: "We seem to have a sufficient supply of manganesic ores, which are used in the production of spiegeleisen, but our supply of these ores has not been fully developed, because of the very low prices at which the spiegeleisen itself, of foreign manufacture, could be obtained. We manufactured, however, in this country last year 24,574 net tons of spiegeleisen, partly from domestic and partly from foreign ores."

Mr. S. T. Wellman says: "As most American spiegel is made from foreign ore, it is of about the same character as foreign spiegel."

Mr. Robert Forsyth says: "Very little of the spiegel made here is as good as the foreign article."

Mr. W. F. Mattes says: "Quality slightly inferior to best imported, and supply inadequate."

Mr. E. S. Moffat says: "There is not much American spiegel on the market, and in the manufacture of that which is made by some of the Bessemer steel works for their own use, I think foreign ores are used pretty liberally. Probably the average of American spiegel is a little behind the average of foreign spiegel in quality."

Mr. Alexander H. Sherrerd says: "It can be made just as good by practice. We have every requisite. Not enough attention has been given to the subject."

Mr. John Birkinbine says: "It can be made equal to imported."

The last two replies point rather to the future capabilities of the country than to the existing state of the industry. So far as can be ascertained, American spiegel, made exclusively from native ores, is not at present as highly esteemed as the imported spiegel; though, allowing the percentage of manganese to be the same, there should be no difference. But while spiegel is an essential in the making of steel, it does not form a large item in the total cost. Our steel-makers could manage very well without foreign spiegel; and, as Mr. Sherrerd points out, too little attention has been given to the manufacture of spiegel from native manganiferous ores.

Production of spiegel in the United States.

	Net tons.
1875	7,832
1876	6,616
1877	8,845
1878	10,674
1879	13,931
1880	19,603
1881	21,086
1882	21,963
1883	24,574
1884	33,893

(From the annual report for 1884 of the secretary of the American Iron and Steel Association.)

STEELS.

THE CAPABILITIES OF AMERICAN WORKS.

The following question was addressed to the several gentlemen whose replies are quoted below:

"Can American works (as now equipped) produce any grade of steel which might be called for by Government specifications, for armor and guns, equal, metallurgically, to foreign?"

Prof. Andrew S. McCreath, of Harrisburg, says: "Pennsylvania steel works can produce the necessary quality and quantity of steel for guns and armor plate equal to the best; but without perhaps at present the machinery to handle and work properly steel for the largest-sized guns. This is simply because such machinery is not required for their general run of work. American ores can be used alone to produce the finest quality of steel."

Mr. W. F. Mattes, of Scranton, says: "Yes, in limited quantities. In special cases a little time for experimenting may be required."

Mr. E. S. Moffat, of Scranton, says: "At present only to a limited extent; but with sufficient encouragement this capacity would be rapidly increased."

Mr. Robert Forsyth, of the Spang Steel and Iron Company, Pittsburgh, says: "A number of American works can produce steel for these purposes equal to anything imported, but not, as yet, in the large masses which are needed for guns and armor."

Major Bent, of the Pennsylvania Steel Works, Harrisburg, says: "They can."

Mr. John Birkinbine, of Philadelphia, says: "They can, if specifications are prepared by practical men. Any specified grade can be made, but possibly not the quantity required."

Mr. Alexander H. Sherrerd, chemist of the Lackawanna Iron and Coal Company, Scranton, says: "Most decidedly they can. All that is necessary for American steel-makers to furnish the best of steel for all purposes is care and intelligence in manipulation."

RELATIVE COST OF AMERICAN-MADE STEEL.

In answer to the following question, "Under existing conditions, about what will be the additional cost of American-made steel of the grades required, as compared with foreign steel of the same quality laid down in the United States duty free?"—

Professor McCreath replies: "I have not the necessary data to properly answer this question; but with steel rails in England at $25 and American rails at $27.50, without profit to either party, the difference in cost cannot be so very much."

Mr. E. S. Moffat says: "Probably about 25 per cent."

Mr. W. F. Mattes, says: "Generally the higher the grade the greater the difference, because of increased percentage of labor items. For high qualities, say 30 per cent."

Mr. Alexander H. Sherrerd says: "The difference in price of labor should be the only factor."

THE CHOICE OF STEELS.

Replies to questions addressed to experts regarding the choice of steel for making heavy, high-powered rifles elicited very discordant replies. The answer will evidently depend upon the system of construction

adopted. The Gun Foundry Board recommend open-hearth steel forged by hydraulic pressure, the guns to be built by shrinking steel hoops upon a steel tube. For guns to be cast solid (which under the existing state of the art are necessarily only of the smaller calibers) either open-hearth or Bessemer steel could be used, perhaps without forging. It is within the possibilities that the system of fluid compression may be so far perfected as to admit of castings of sufficient size to be made sufficiently dense and homogeneous to be utilized for making the largest-sized guns in single masses; but at present the balance of opinion is decidedly in favor of built-up guns, in which all of the parts are forged, either by steam-hammers or by the hydraulic press. The latter is strongly recommended by the Board. The built-up system admits of smaller masses, which are easier to cast, forge, and work, and which are more conveniently transported from the steel works to the gun factory. It should be noted that the Gun Foundry Board, in making their suggestions, have followed the best European authorities, and propose nothing which is untried and not already adopted in actual practice abroad.

For armor, the question is even in a more unsettled state than for guns. The selection of metal and the thickness used depend, of course, on the power of the guns to be opposed and the character of the projectiles to be resisted, and, if the armor is for vessels, upon the size and construction of the latter. Besides, there are limits to the thickness of plate which can be forged with existing machinery. A series of thin plates does not offer the same resisting power as a single heavy plate. At present, in the race between guns and armor, the former seem to have a decided advantage. The recent trials at Spezzia have demonstated that the 100-ton guns are capable of overcoming any armor now carried by ships, provided the blow be delivered squarely and from a reasonable distance. Even the compound armor—a hard-faced, tough-backed combination, but still of solid plate—of which so much was anticipated, has proved disappointing. However, the guns to be met in actual warfare will seldom, for some time at least, be of such a destructive character. Bessemer steel is the cheapest; crucible steel, the hardest; open-hearth steel, probably the most uniform; while wrought-iron is a tough and reliable material, which, though punctured more readily than steel and deficient in deflective or breaking effect upon the projectiles, does not shatter. The monograph of Lieutenant Very, U. S. N., on the evolution of armor, and that of Lieutenant Jaques, U. S. N., amplifying the report of the Gun Foundry Board, give very full accounts of the present status and kinds of armor; and it is not attempted in these brief notes to add to the exhaustive discussions referred to. There would be no difficulty in obtaining American steel for armor plate fully equal in quality to foreign, though in masses of limited size; but the appliances for forging and machining are wanting.

SHOULD SHIPS AND GUNS BE CONSTRUCTED AT GOVERNMENT WORKS OR AT PRIVATE ESTABLISHMENTS?

It is difficult to say. The nation which is most successful in its armament, and operates on the largest scale—Great Britain—pursues both methods; and the contract system there seems to answer well; at all events, there are no open scandals on account of failure on the part of the contractors in point of quality, nor as to exorbitant costs. There is, it is true, much greater competition between private builders in Great Britain than can be expected in this country for some time.

It should be remembered, however, that when our officials have fully determined what classes of vessels, what system of armor, what type of guns they really want, it is merely a question of drawing up careful specifications, making searching tests of material and workmanship, and rigidly insisting upon a strict compliance with the plans. Thus far, unfortunately, a remarkable diversity of opinion has been developed. Surely we have men of sufficient capability in designing and honesty in executing to insure satisfactory results as to quality; while, if our naval and ordnance services are to be developed to an efficient point, the size of the orders to be filled will create a certain amount of competition, since, when new and extensive plant is required, new bidders will be induced to appear. On the other hand, in the past the Government arsenals and yards have turned out excellent work, though not on a very extensive scale. As to the relative expense of the two systems, no opinion is here ventured.

For the manufacture of heavy guns the Gun Foundry Board recommend the establishment of two gun factories, one for the Army and one for the Navy, at which the parts of the guns shall be machined and assembled; but that the steel masses required shall be purchased from private steel works. A similar arrangement would answer in armor-making, but one works being required. It is probably true that a saving in expense, provided work is to be prosecuted on a large scale, would be made if the making of the steel and its manufacture into guns or armor could be conducted together, as is done in some European works; but it is not considered advisable for the Government to enter into the business of a manufacturer any further than it is compelled to. Should it be deemed best to buy the armor, in a finished state, from private works, the necessary appliances for rolling heavy plates can be attached to a favorably situated Bessemer mill at a cost of about $400,000, as estimated by Mr. Mattes and others. No company, of course, could afford to change their plant unless assured of practically steady work for a term of years.

OPEN-HEARTH STEEL WORKS.

The following list of the open-hearth steel-makers of the United States is appended in view of the preference which has been expressed for this kind of steel as a material for high-powered guns. The list is taken from the Directory of the Iron and Steel Works of the United States for 1884, published by the American Iron and Steel Association. It should be noted, however, that in some cases the capacities quoted represent the actual working limit, while other furnaces are rated according to the nominal capacities as estimated at the time of construction:

NEW HAMPSHIRE.

Nashua Iron and Steel Company, Nashua. One 10-ton Siemens furnace.

VERMONT.

Saint Albans Iron and Steel Works, Saint Albans. One 10-ton Siemens furnace. Idle.

MASSACHUSETTS.

Bay State Iron Company, Boston. One 6-ton Siemens furnace. Not in operation for several years.

Norway Steel and Iron Company, 23 Mason Building, Boston. Three 10-ton Siemens furnaces.

NEW YORK.

Johnson (Isaac G.) & Co., Spuyten Duyvil. One 8-ton open-hearth furnace.

NEW JERSEY.

Newark Steel Works, Benjamin Atha & Co., Newark. One 7-ton Siemens furnace.

PENNSYLVANIA.

Bethlehem Iron Company, Bethlehem. Building two 15-ton Siemens-Pernot furnaces.
Black Diamond Steel Works, Park, Brother & Co., Pittsburgh. Deadline to give information.
Cambria Iron Company, Johnstown. Two 12-ton Siemens-Pernot furnaces.
Chester Rolling Mills, Chester. Two 15-ton Siemens furnaces.
Fort Pitt Foundry, Mackintosh, Hemphill & Co. (limited), Pittsburgh. Two 7-ton Siemens furnaces.
Frankford Steel Works, Adam Tindel, Frankford, Philadelphia. Building a 5-ton Siemens furnace.
Glenwood Steel Works, Leishman, Gordon & Snyder, Pittsburgh. One 5-ton Siemens furnace.
Grover, Gier & Co., limited, Danville; Philadelphia office, 330 Walnut street. One 20-ton Siemens furnace.
Hussey, Howe & Co., limited, Pittsburgh. One 7-ton Siemens furnace.
Juniata Iron and Steel Works, Shoenberger & Co., Pittsburgh. Two 12-ton Siemens furnaces.
Leechburg Sheet-Iron and Tin Plate Works, Kirkpatrick & Co., limited, Leechburg. Office, 143 First avenue, Pittsburgh. One 10-ton Siemens furnace.
Linden Steel Company, limited, Pittsburgh. One 7-ton and one 10-ton Siemens furnace.
Midvale Steel Company, Nicetown post-office, Philadelphia. One 7-ton and two 12-ton Siemens furnaces.
Pennsylvania Steel Company, Steelton. Office, 208 South Fourth st., Philadelphia. Two 30-ton Siemens furnaces.
Singer, Nimick & Co., limited, Pittsburgh. One 10-ton Siemens furnace.
Soho Iron Mills, Moorhead & Co., Pittsburgh. One 12-ton Siemens furnace.
Spang Steel and Iron Company, limited, Pittsburgh. One 7-ton Siemens furnace completed and one 10-ton Siemens furnace building.
Standard Steel Casting Company, Thurlow, Delaware County. One 10-ton Siemens furnace.
West Penn Steel Works, Joseph G. Beale, Leechburg. One 7-ton Siemens furnace.

KENTUCKY.

Mitchell, Tranter & Co., Second and Race streets, Cincinnati. Works at Covington, Ky. One 7-ton Siemens furnace.

TENNESSEE.

Roane Iron Company, Chattanooga. Two 10-ton Siemens furnaces.

OHIO.

Burgess Steel and Iron Works, Portsmouth. One 8-ton Siemens furnace.
Canton Steel Works, Bolton Steel Company, Canton. One 10-ton Siemens furnace.
Cleveland Rolling Mill Company, Cleveland. Three 7-ton and two 15-ton Siemens furnaces.
Otis Iron and Steel Works, Otis Iron and Steel Company, Cleveland. Four 15-ton Siemens furnaces.
Portsmouth Iron and Steel Works, John Means, trustee, Ashland, Ky. Works at Portsmouth. One 10-ton Siemens furnace.
Solid Steel Company, Alliance, Stark County. One 10-ton open-hearth furnace.
Whitley, Fasler & Kelly, Springfield. Building an open-hearth furnace.
Youngstown Steel Company, Youngstown. One 20-ton Siemens furnace.

ILLINOIS.

Calumet Iron and Steel Company, Chicago. Four Siemens furnaces.
Springfield Iron Company, Springfield. Two 20-ton Siemens-Pernot furnaces.

CALIFORNIA.

Pacific Rolling Mill Company, 16 First street, post-office box No. 2,032; San Francisco. One Siemens furnace.

UNITED STATES.

Total number of open-hearth steel works in the United States, 35 completed and 3 building; number of furnaces, 58 completed and 5 building.

GENERAL CONCLUSIONS.

The United States is metallurgically independent as to its iron ores, iron, and steel. Economically speaking, it is at a disadvantage in point of costs of materials and labor. The difference is about one-quarter, certainly within one-third, in excess of the price of similar steels for arms and armor imported from foreign countries, and laid down on the eastern seaboard free of duty. American works can produce any grade of iron or steel demanded, though for special qualities and unusual quantities some modifications in processes and plant may be required. Given an order for metal of a certain hardness, tensile strength, &c., if the specifications are within the present capabilities of foreign establishments, that metal can be made in the United States. In time of peace it is reasonable to pay the additional cost, for the sake of securing entire independence in the event of war. We have skilled engineers and intelligent artisans. We are lacking in experience, but, *per contra*, we can profit by that of others without undergoing all the experimental stages. Innovations, if meritorious, succeed with great rapidity here. We should not waste money in unnecessary experiment. Too many crude failures have been made already. We should know first of all exactly what we want, then the getting of it becomes a matter of mere detail. Whatever plans are adopted must be far-sighted, aimed toward a steady development of our resources. In mechanical appliances, such as heavy rolls and hammers, our shops are far behind the times in regard to size, but not as to pattern, the lighter machinery being considered fully equal to that of foreign works.

IRON-SHIP BUILDING IN THE UNITED STATES.

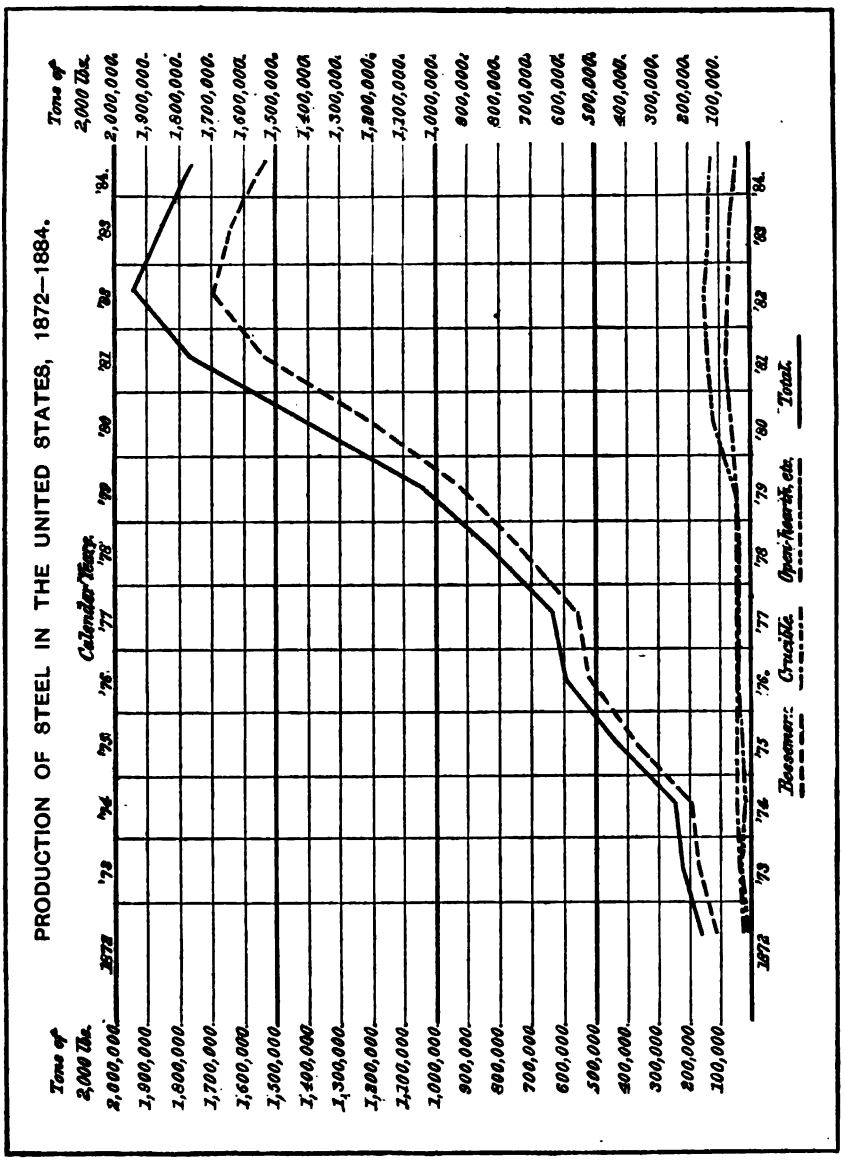
The following table, compiled from the reports of the Assistant Register of the United States Treasury, gives the number and tonnage of iron vessels built in the United States in each fiscal year since 1868, when their construction in this country was commenced:

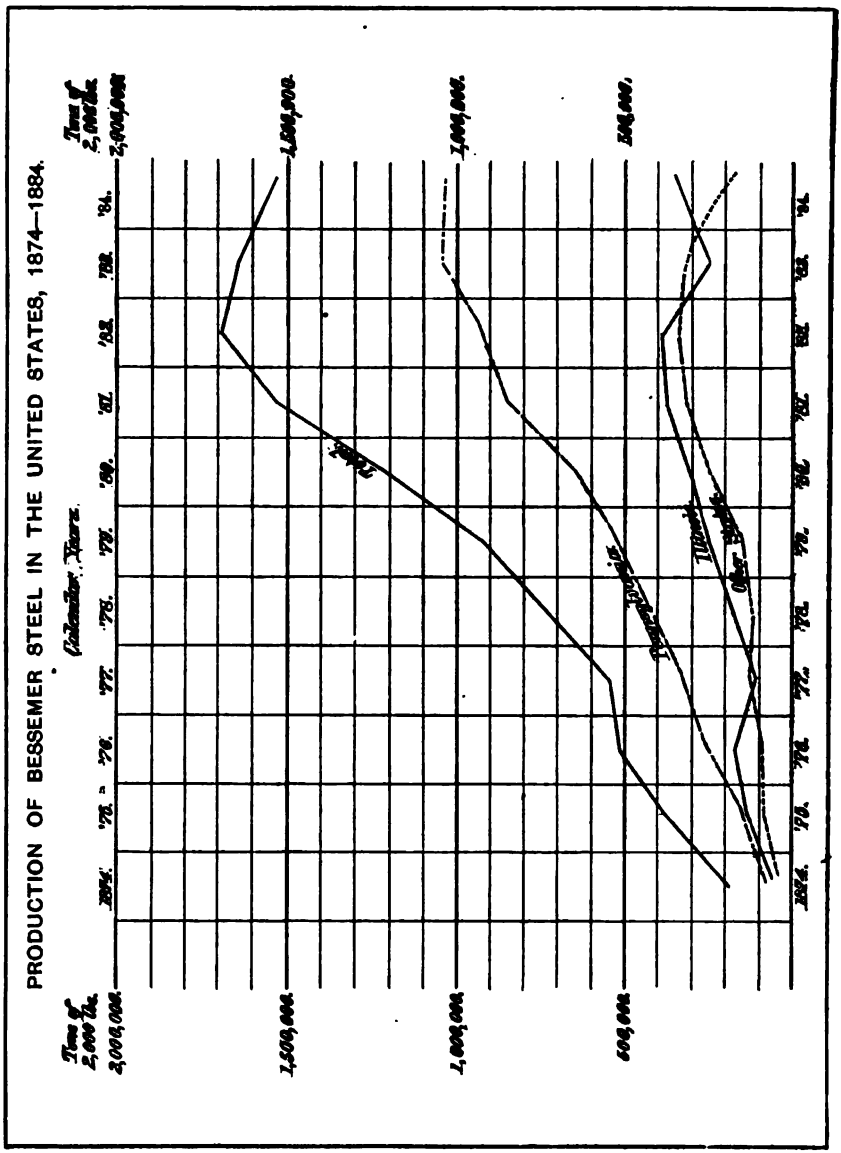
Years.	No.	Tonnage.	Years.	No.	Tonnage.
1868	....	2,801	1876	25	21,346
1869	....	4,584	1877	7	5,927
1870	....	8,281	1878	32	26,960
1871	....	15,479	1879	24	22,008
1872	20	12,766	1880	31	25,582
1873	26	26,548	1881	42	28,356
1874	23	33,097	1882	43	40,097
1875	20	21,632	1883	35	39,646

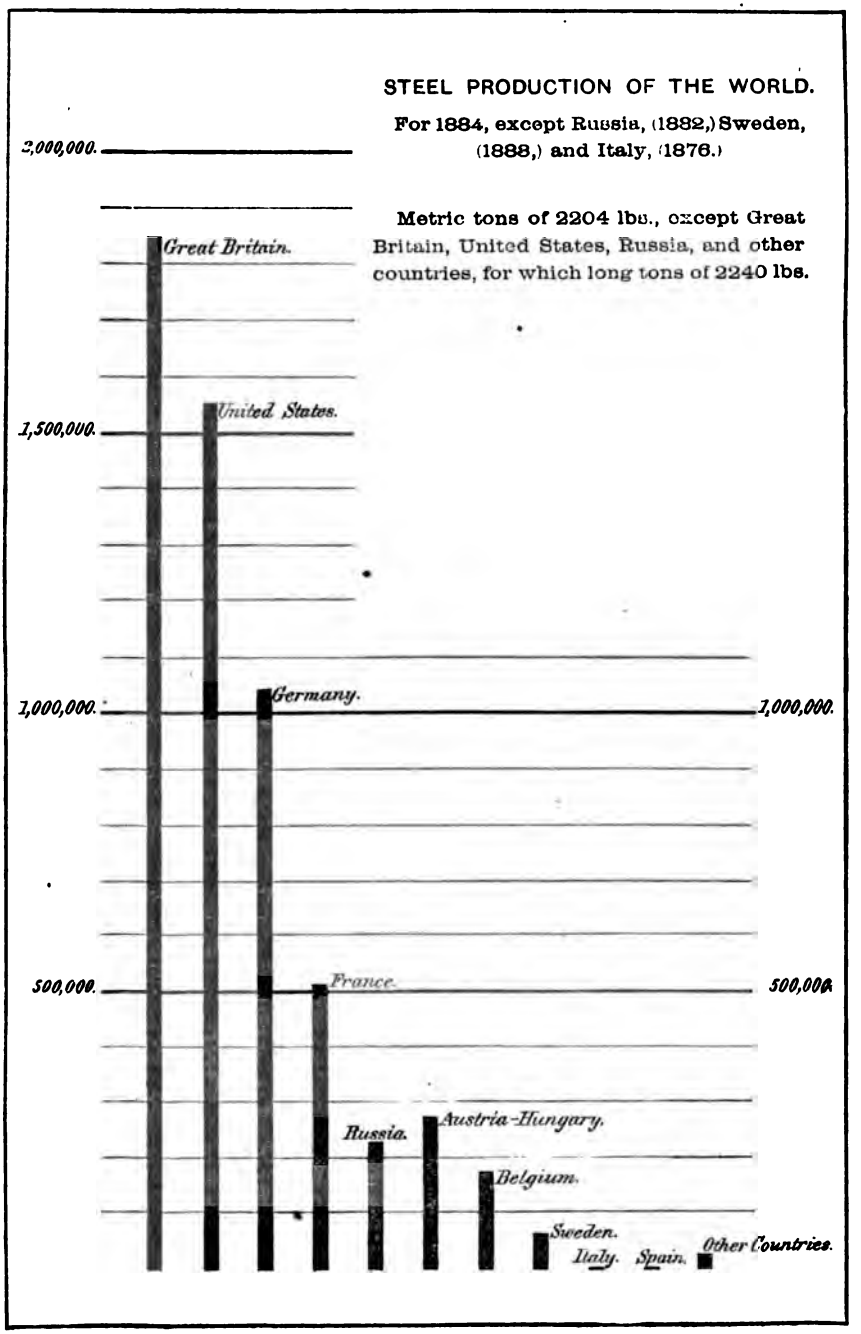
STATISTICAL CHARTS.

The following diagrams, illustrating the production of the different kinds of steel in the United States, and comparing this production with that of other countries, have been drawn by Mr. Williams from the figures published in the annual report of Mr. James M. Swank, secretary of the American Iron and Steel Association, for 1883.*

* Corrected for 1884. (Chairman.)


PRODUCTION OF STEEL IN THE UNITED STATES, 1872–1884.
Tons of 2,000 lbs.
Calendar Years.
Bessemer.
Crucible.
Open-hearth, etc.
Total.


PRODUCTION OF BESSEMER STEEL IN THE UNITED STATES, 1874–1884.
(Calendar Years.)
Tons of 2,000 lbs.
4,000,000
1,500,000
1,000,000
500,000
Tons of 2,000 lbs.
2,000,000
1,000,000
500,000
1874.
'75.
'76.
'77.
'78.
'79.
'80.
'81.
'82.
'83.
'84.
Rails.
Total.
Open Hearth.
Steel Rails.


STEEL PRODUCTION OF THE WORLD.
For 1884, except Russia, (1882,) Sweden, (1888,) and Italy, (1876.)
Metric tons of 2204 lbs., except Great Britain, United States, Russia, and other countries, for which long tons of 2240 lbs.
2,000,000.
1,500,000.
1,000,000.
500,000.
Great Britain.
United States.
Germany.
France.
Russia.
Austria-Hungary.
Belgium.
Sweden.
Italy.
Spain.
Other Countries.

STATEMENT OF MR. JAMES M. SWANK.

PHILADELPHIA, PA., *February* 12, 1885.

The CHAIRMAN. Please state your name and present position.

Mr. SWANK. James M. Swank, vice-president of the American Iron and Steel Association.

The CHAIRMAN. What is your age, and of what scientific associations are you a member? Please state your experience in, and what statistics you have prepared on, the subject this committee is investigating.

Mr. SWANK. I am in my fifty-third year. I have never been practically engaged in the manufacture of iron or steel, but I can properly say that for more than thirty years I have been familiar with the manufacture of iron, and that during the half of this period I have been familiar also with the manufacture of steel—in both cases, however, possessing only that familiarity which may be said to pertain to close observation and careful study of these industries. My knowledge of the industries mentioned, such as it is, is commercial, economic, statistical, and historical. My position in connection with this association has not required the possession of practical technical knowledge, and I have never pretended to possess it. I do claim, however, to be reasonably familiar with the other features of the manufacture of iron and steel which have been above enumerated. I edited and published a newspaper in an iron town for many years, and during my twelve years' connection with this association I have compiled and edited all its publications, and have recently published a history of the manufacture of iron in all ages. I am not an active member of any scientific association.

The CHAIRMAN. Is there material in this country out of which the best gun-steel can be made?

Mr. SWANK. Without being familiar with all the qualities that would be required for best gun-steel, I can say that my study of the iron and steel industries of the world fully convinces me that this country can produce, wholly from native materials, as good steel as is made in any other country.

The CHAIRMAN. Why do steel manufacturers import foreign material?

Mr. SWANK. Steel manufacturers near the Atlantic coast can obtain foreign iron ore at lower prices than they can obtain domestic ore of equally good quality. As I have elsewhere stated, our importations of foreign iron ore for use in the manufacture of steel amount annually to about one-fourth of the total quantity of iron ore that is used for this purpose. We still import some spiegeleisen for use in the Bessemer and open-hearth processes, and also some pig iron for use in the open-hearth, but solely for economic reasons.

The CHAIRMAN. How can the Government best be supplied with modern heavy ordnance; whether wholly in Government works, or partly in such works and partly by contracts with private builders, or wholly in private yards? In case of divided labors how should the division be made?

Mr. SWANK. So far as this question is intended to deal with purely technical details I cannot answer it, but there can be no doubt whatever that if sufficient inducement be offered to our steel manufacturers they would be willing and competent from every standpoint to engage in the manufacture of the steel to be used in making the guns, and in the shaping and finishing of the guns themselves. What Krupp and other steel-makers have done in Europe can be done here if required. The weight of testimony already gathered by the Gun Foundry Board clearly sustains the proposition that the best results may be expected from the adoption in our country of the French system, which looks to private manufacturers for gun material to be fashioned into guns in Government factories. The conclusions of the Gun Foundry Board appear to be generally approved by our steel manufacturers. My own opinion is that it would be a useless waste of money and a great risk for the Government to establish works for the manufacture of steel for gun material when it can so easily and so surely obtain steel for this purpose from works that are already established in our country and are well known to be both skillfully and economically managed.

The CHAIRMAN. What is the steel-producing capacity of the Bessemer and open-hearth plants in the United States?

Mr. SWANK. In 1882 the Bessemer-steel works of the United States produced 1,696,450 net tons of steel ingots, and their present estimated capacity is 2,490,000 net tons of ingots per annum. In 1882 the open-hearth steel works of the country produced 160,542 net tons of steel ingots, and their present estimated capacity is 550,000 net tons of ingots per annum. As all Bessemer and open-hearth works could not be expected to be in operation at the same time, and each working to its fullest capacity, it would be fair to say that, if an extraordinary demand for their products should arise, we could in one year make 2,000,000 net tons of Bessemer ingots and 400,000 net tons of open-hearth ingots.

A BIRDS-EYE VIEW

OF THE

PRODUCTION AND CHARACTERISTICS

OF

IRON ORES IN THE UNITED STATES,

WITH

STATISTICS OF IMPORTS OF FOREIGN IRON ORES IN RECENT YEARS.

By JAMES M. SWANK,

VICE-PRESIDENT OF THE AMERICAN IRON AND STEEL ASSOCIATION.

THE PRODUCTION AND CHARACTERISTICS

OF

IRON ORES IN THE UNITED STATES.

[The following paper was contributed to the special report on the mineral resources of the United States, by Albert Williams, jr., Chief of the Division of Mining Statistics and Technology of the United States Geological Survey, Department of the Interior, published in 1885.]

In the preparation of the following essay an attempt has been made to bring together in popular form the leading facts connected with our iron-ore resources and our domestic and foreign iron-ore supplies. No other purpose has been entertained. The facts presented will afford a bird's-eye view of one of the great industries of our country, and of its relation to our extensive iron and steel industries and to the many other industries that are dependent upon them.

Our imports of iron ore.—Previous to 1879 the quantity of iron ore imported into the United States was not recorded, but it did not amount to 100,000 tons in any one year. The quantity of iron ore imported from 1879 to 1885, both years included, was as follows, in tons of 2,240 pounds—the foreign value of the importations in these years is also given.

Years.	Gross tons.	Values.
1879	284,141	$681,467
1880	493,408	1,436,809
1881	782,887	2,222,652
1882	589,655	1,640,564
1883	490,875	1,207,991
1884	487,820	1,123,678
1885	425,870	953,596

The American Iron and Steel Association has ascertained the destination of 439,183 gross tons of the 487,820 tons of iron ore that were imported in 1884. This information we present in the following table:

States and districts.	Gross tons.
New York	9,562
New Jersey	1,918
Lehigh Valley, Pennsylvania	147,891
Schuylkill Valley, Pennsylvania	54,211
Upper Susquehanna Valley, Pennsylvania	3,076
Lower Susquehanna Valley, Pennsylvania	158,961
Allegheny County, Pennsylvania	20,288
Conemaugh Valley and Youghiogheny Valley, Pennsylvania	40,169
Charcoal furnaces, Pennsylvania	1,492
Maryland	600
Ohio	1,615
Total	439,183

These figures leave 48,637 tons unaccounted for, which were chiefly used in New York, New Jersey, Ohio, and Washington Territory. The figures presented in the table for Pennsylvania and Maryland we believe to be complete, or very nearly so. Of the 439,183 tons accounted for, 81,758 tons were used in the manufacture of pig-iron for general purposes, while the remainder was used in the manufacture of Bessemer pig-iron and spiegeleisen.

Our imports of iron ore are derived from many countries, but principally from Spain. The following table of imports of iron ore into the United States in the fiscal year which ended June 30, 1884, shows the sources of foreign supply for that year; statistics for the calendar year 1884 are not obtainable:

Countries.	Gross tons.	Values.
Spain	374,943	$829,432
Italy	57,664	154,857
French Possessions in Africa	56,448	109,920
Turkey in Asia	4,875	76,601
Dominion of Canada	29,125	71,900
England	7,855	23,873
Greece	12,530	18,615
France	4,566	18,410
Portugal	6,299	13,942
Mexico	1	5
Total	553,806	1,317,546

The impulse that was given to the importation of iron ore in 1879, 1880, and 1881 was due partly to the high prices asked for Lake Superior ores, partly to a scarcity of iron ores on the Atlantic coast that were suitable for the manufacture of Bessemer pig iron, and partly to the revival in the American iron industry in these years which created an extraordinary demand for iron ores for general as well as for special purposes. The first two of these influences have now largely disappeared and the last one has entirely disappeared. Lake Superior prices have fallen, owing partly to the opening of new mines in that district, and new sources of supply of Bessemer ores have been developed in the East. But in the mean time American capitalists have made extensive investments in Cuban and Canadian iron-ore mines, the product of which is now being brought to this country for the manufacture of Bessemer pig-iron, while increasing use of Spanish and Elba iron ores is being made by Eastern furnace owners in the manufacture of pig-iron for the general market and for sale to our steel manufacturers.

Much the larger part of the iron ore that was imported in 1882, 1883, and 1884 came from Bilbao and from Mediterranean ports for use in the manufacture of Bessemer and other pig-iron chiefly on or near the Atlantic coast, the inducements to import it being its richness, purity, and cheapness. The causes which influenced importations in 1879, 1880, and 1881 taught our people the value of foreign ores, and unless prevented by a high duty such foreign ores as have been used on the Atlantic coast will continue to be imported. The duty on iron ore was changed by the tariff which went into effect July 1, 1883, from 20 per cent. ad valorem to 75 cents per ton of 2,240 pounds. That foreign ore can be brought to this country at low prices is due in part, of course, to the very great cheapness of the labor that is employed in mining it, but largely also, to the cheapness of ocean freights. The vessels which carry the ore are usually "ocean tramps," which carry grain, petro-

leum, lumber, and occasionally cotton to Europe, and the owners of which are glad to bring back ore at low rates rather than come in ballast. These vessels are all owned abroad.

The following table shows the quantities and values of iron ore imported into the various customs districts of the United States in the four calendar years 1881, 1882, 1883, and 1884. For this and the preceding table we are indebted to the courtesy of Hon. Joseph Nimmo, jr., chief of the Bureau of Statistics of the Treasury Department:

Districts.	1881.		1882.		1883.		1884.	
	Gross tons.	Values.	Gross tons.	Values.	Gross tons.	Values.	Gross tons.	Values.
Baltimore	375,798	$1,005,496	243,182	$654,629	236,998	$612,626	184,521	$357,136
Beaufort, S. C	.....	.....	.....	.....	1,473	4,243	1,769	5,005
Boston	716	2,867	1,664	3,322	2,470	5,277	2,865	7,765
Buffalo Creek	2,492	7,320	273	755	.....	.....	.....	.....
Champlain	.....	.....	2	7	5	28	.....	.....
Cuyahoga	10,500	37,675	9,420	33,181	6,525	17,810	30,964	121,154
Detroit	617	1,646	48	98	.....	.....	10	27
Genesee	8,716	25,961	6,851	21,651	784	1,740	758	1,897
Huron	264	770	264	677	14	4	10	150
New York	196,419	641,344	145,909	421,776	36,800	94,236	29,401	82,995
Oswegatchie	3,418	10,650	905	2,783	942	2,866	.....	.....
Oswego	13,612	44,026	37,635	120,008	17,862	40,744	11,179	27,856
Perth Amboy	13,671	48,323	31,558	101,859	10,082	29,189	50,836	124,257
Philadelphia	155,564	394,952	111,944	279,818	170,420	386,386	169,507	388,900
Puget Sound	1,100	1,622	.....	.....	3,521	7,084	2,012	4,024
Sandusky	.....	.....	.....	.....	.....	.....	2,177	5,387
Vermont	.....	.....	.....	.....	2,979	5,758	1,831	7,125
Total	782,887	2,222,652	589,655	1,640,564	490,875	1,207,991	487,820	1,133,678

The Juragua Iron Company (limited), an American company, has opened extensive mines of iron ore on the southeastern coast of Cuba, which it purchased early in 1883, and from which shipments to this country commenced in August 1884. These shipments have since aggregated many thousand tons, and they promise to become in a short time a leading feature of our iron-ore imports. Whether they will result in reducing the supply heretofore received from Spain is yet a matter of conjecture. The quantity of iron ore shipped in 1884 amounted to about 20,000 tons; the shipments in 1885 will probably reach 100,000 tons. The ores from these mines are used for Bessemer purposes. They are rich in iron and very low in phosphorus. The Juragua Iron Company (limited) is composed of the Bethlehem Iron Company, the Pennsylvania Steel Company, and Mr. Alfred Earnshaw.

Near Trenton, in the province of Ontario, in the Dominion of Canada, a company of American and Canadian capitalists, which was organized in 1883, has made extensive arrangements, involving a large expenditure of money, for mining iron ore from several mines which have been developed and from others which have been located. The ores of these mines are said to be well adapted to the manufacture of Bessemer steel. The shipping port is at Weller's Bay, on Lake Ontario, 4 miles south of Trenton. The shipments to the United States during 1884 amounted to about 40,000 tons. An increase in the shipments for 1885 is expected. The principal promoters of the enterprise are Mr. S. J. Ritchie, of Tallmadge, Ohio; Hon. S. Burke, Hon. Henry B. Payne, and Mr. William Chisholm, of Cleveland, Ohio; the Messrs. McMullen, of Trenton and Picton, Ontario, and the Messrs. Coe, of Madoc, Ontario.

The following table shows the number of tons of iron ore imported during the last six years into each of the leading iron-manufacturing countries of the world:

Years.	Great Britain.	France.	Germany.	Belgium.	United States.
1879	1,063,692	941,812	380,000	614,584	284,141
1880	2,634,401	1,168,215	607,007	921,784	493,406
1881	2,449,277	1,287,870	615,490	1,169,206	732,887
1882	3,282,496	1,425,870	785,360	1,206,717	589,655
1883	3,178,310	1,601,217	800,373	1,612,469	490,875
1884	2,728,672	1,412,710	980,442	1,487,748	487,820

It will be seen from this table that the United States is the smallest importer of iron ore of all the countries mentioned. If we consider its prominent place among these countries, being second in the production of iron and steel, it is very much the smallest importer.

Production of iron ore in the United States in 1883 *and* 1884.—Full statistics of the production of iron ore in the United States are not obtained, and cannot be obtained, except in census years. The annual production of iron ore in the whole country may, however, be very accurately estimated. The average quantity of iron ore that is used in producing a ton of pig-iron in the United States, in addition to the mill cinder that is used in some furnaces, is shown by the census of 1880 to be about 1.9 tons, while the production of pig iron is definitely ascertained from year to year by the American Iron and Steel Association, so that the quantity of iron ore produced in any year and used at our blast furnaces is approximately ascertained by multiplying the year's production of pig-iron by 1.9 and deducting from the product the quantity of iron ore imported. By this method we obtain the following results for 1884. The pig-iron produced, 4,097,868 gross tons, multiplied by 1.9 gives 7,785,949 tons, from which, if we deduct 487,820 tons of iron ore imported, we have 7,298,129 tons as the home production of the year that was used at our blast furnaces. This country also annually produces in forges directly from the ore about 40,000 gross tons of blooms and billets, representing about 120,000 tons of native ore. The largest and best of these forges are located in the Champlain district of New York, while others are found in Tennessee, North Carolina, Virginia, and Missouri. We also use some iron ore as fettling in the puddling furnaces of our rolling mills, and the quantity so used in 1884 we estimate, upon the basis of the census figures of 1880, to have amounted to about 300,000 tons, which, added to the domestic ore used in our blast furnaces and forges, gives us 7,718,129 gross tons as the probable production and consumption of domestic iron ore in 1884. This calculation takes no account of ore produced and not consumed.

That the figures above given of the production and consumption of iron ore in the United States in 1884 are correct is proved by statistics obtained by the American Iron and Steel Association. In response to a circular letter addressed to all the manufacturers of iron and steel in the country, and which was very generally answered, detailed information was furnished which indicates that the aggregate consumption of domestic iron ore in 1884 amounted to 7,639,581 gross tons. This result is so close to the result reached by the method adopted in the preparation of this paper that it may safely be assumed that the quantity given by that method (7,718,129 tons) is correct and should stand.

As incidental to the present inquiry it may be stated that, if we elim-

inate the mill cinder from the census statistics of 1880, and the probable amount of pig iron that was produced with it, it will appear that an average of 2.03 tons of iron ore was in that year required to produce a ton of pig-iron. This is below the average in the leading iron-producing countries of Europe. Great Britain averages 2.4; Germany, 2.6; France, 2.6; and Belgium, 2.7.

The following statistics showing the production of domestic iron ore in 1883 and 1884 in certain leading districts have been obtained from reliable sources of information. As will be observed, the figures for 1884 embrace more than half the total estimated consumption of that year.

Districts.	1883.	1884.
	Gross tons.	*Gross tons.*
Lake Superior mines of Michigan and Wisconsin	2,352,288	2,455,924
Vermillion Lake mines of Minnesota	Not opened	62,124
Missouri	295,430	233,225
Cornwall, Pennsylvania	363,143	412,320
Chateaugay mines, near Lake Champlain	194,704	214,394
Other Lake Champlain mines, including the Port Henry and Crown Point mines	305,300	290,500
New Jersey	521,416	398,710
Salisbury district, Connecticut	35,000	25,000
Hudson River Ore and Iron Company, New York	20,000	90,000
Total	4,087,281	4,177,197

In 1882 the Lake Superior region and the State of New Jersey reached respectively the largest production of iron ore in their history. In the former 2,947,392 gross tons were produced, and in the latter the production was 932,762 tons.

The remainder of our domestic supply of iron ore in the two years mentioned, as well as in previous years, was obtained from mines located in all the States and Territories that produce pig-iron, and located, too, in nearly every case in close proximity to the blast furnaces. There are very few States and Territories in the Union in which iron ore has not been discovered. The large number of "local mines" in so many States and Territories indicates not only the wide distribution of iron ore in our country, but also the existence of a disposition among the people of all sections to develop the various deposits as promptly as the wants of the country require. The iron-making instincts of our people are shown fully as much in their search for native iron ores and in the means they have used to develop them as in their readiness to adopt the best modern methods of manufacture. A less energetic people, for instance, would have been appalled by the difficulties which confronted the first shippers of iron ore from the Lake Superior region, and there are not to be found anywhere in the world to-day better or more expensive machinery and appliances for the mining of iron ore than are to be found in that district.

The latest illustration we have had of the enterprise of our people in seeking at home for new sources of supply of iron ore of a quality or character that had not previously been discovered, or discovered in insufficient quantities, is seen in the search of our Bessemer steel manufacturers for manganiferous iron ores in Michigan, Virginia, Georgia, Alabama, and Arkansas—a search which has resulted in a considerable increase during the past year in our production of spiegeleisen and ferro-manganese. The production amounted to 33,893 net tons, of which New Jersey produced 7,058 tons, Pennsylvania 26,509 tons, and Colorado 326 tons. The following table shows the production of these

articles in the United States since 1875. In each year foreign as well as domestic ore was used, but in 1884 there was a marked diminution in the use of foreign ore.

Years.	Net tons.	Years.	Net tons.
1875	7,832	1880	19,998
1876	6,616	1881	21,986
1877	8,845	1882	31,988
1878	10,674	1883	24,574
1879	13,981	1884	33,898

New and old iron-ore fields in the United States.—Of the important deposits of iron ore that have been developed in this country and are still worked the Salisbury district in Western Connecticut was developed as early as 1731; the Schuylkill Valley mines in Pennsylvania were developed in 1716, and the Cornwall "ore hills" in the same State about 1735; the magnetic ore mines in Northern New Jersey were opened about 1710; the Sterling mines in Orange County, New York, in 1750; and the Champlain district in the same State about 1800; the Tennessee mines, the mines in Bath County, Kentucky, the Cranberry mines in North Carolina, and the Juniata Valley mines in Pennsylvania near the close of the last century; the Hanging Rock region of Kentucky during the second decade of the present century, and the same region in Ohio during the third decade. The Iron Mountain and Pilot Knob region in Missouri was developed about 1845. The existence of iron ore on the southern shore of Lake Superior, the most celebrated and most productive iron-ore region in this country, was not even discovered until about 1830, and no attempt was made to develop it until 1845, just forty years ago. It is a noticeable fact, however, that, notwithstanding our early enterprise as iron manufacturers, some of the richest deposits of iron ore in this country were not developed, and in some instances were not discovered, until in very recent years. No attempt was made to develop some of these deposits until after the boom of 1879 and 1880, while the development of others was greatly stimulated by that event.

A notice of the location and characteristics of some of the older iron-ore fields above referred to and of all of the most recently developed deposits is demanded by the increasing public interest in the general question. Such illustrative chemical analyses as will be presented have in every instance been obtained from reliable sources.

1. The celebrated Marquette district, in Michigan, the most productive of all the iron-ore districts in the country, is mainly embraced in Marquette County, a small part of it extending northwest into Baraga County. Its principal ports of shipment for the ores that are not consumed in local furnaces are Marquette and Escanaba, the former on Lake Superior and the latter on Lake Michigan. Small quantities of ore are annually shipped from this district at L'Anse, on Lake Superior. There are at present several charcoal furnaces in the district.

The great extent and great richness and purity of the hematite and magnetic iron ores of the Marquette district are too well known to require extended reference. The district is by far the most important iron-ore field in the United States.

We subjoin a collection of fourteen analyses of the ores of the Republic mine, one of the most noted mines of the Marquette district, which we take from Mr. A. P. Swineford's Mineral Resources of Lake

Superior, printed in 1876. This mine is operated by the Republic Iron Company.

Constituents.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	Average.
Metallic iron	65.11	67.75	68.01	69.88	69.24	71.82	68.40	68.23	65.86	69.89	67.55	68.00	68.40	70.60	68.48
Phosphorus	trace	.05	trace	.018	.....	.....	.08	.15	.073	.06	.045	.05	.....	.....	.053
Silica	.....	.....	.....	.....	1.08	.84	.86	3.53	4.63	2.02	2.53	.....	.....	1.10	2.07
Lime	.....	.....	.....	.....	.....	.....	.82	.....	.....	.....	.....	.....	.....	.....	.....
Magnesia	.....	.....	.....	.....	.....	.....	.83	.....	.....	.....	.....	.....	.....	.....	.....

The iron ore of the Champion mine shows 67 per cent. of iron, 3 per cent. of silica, and .03 per cent. of phosphorus. Several analyses of West Republic ore that are before us show iron ranging from 66.483 to 68.583 per cent., and phosphorus ranging from .039 to .054 per cent. Two analyses of the specular ore of the Lake Superior mine give the following results:

Metallic iron	64.831	65.680
Silica	3.600	3.700
Alumina	2.030	2.370
Lime	.550	.700
Magnesia	.600	.350
Phosphorus	.067	.095

2. The Menominee Range district is mainly situated in Menominee County, Michigan, the western part of it extending into Florence County, Wisconsin. This district ranks second in productiveness to the Marquette district. Both districts lie on the southern shore of Lake Superior.

The Menominee district owes its development mainly to the enterprise of the Menominee Mining Company, of Milwaukee. About 1876 this company obtained control of a large extent of country owned by the Lake Superior Ship Canal, Railway, and Iron Company, and by other parties, and at once commenced active operations. In 1877 10,405 tons were shipped, and thereafter shipments rapidly increased, both from the mines of this company and from mines opened by other capitalists. The Menominee Mining Company is still the largest shipper in the district, and the next largest is the Penn Iron Mining Company, a corporation which was organized in 1882, and which represents a large amount of Pennsylvania capital. The ore from this district is all shipped at Escanaba to ports below, except a very small quantity which is used at two local charcoal furnaces.

The ores of the Menominee district are generally red hematites, and partake of the same general characteristics as similar ores of the Marquette district, except that they are as a rule softer. They are found in large deposits. We subjoin analyses of the ores of some of the mines operated by the Penn Mining Company. These analyses were made by the Cambria Iron Company from ores used in its blast furnaces.

Constituents.	Vulcan.	Cyclops.	Norway.	Quinnesec.
Iron	63.930	60.470	58.940	67.05
Silica	6.860	8.380	12.270	4.80
Phosphorus	.013	.009	.016	.01

3. The statistics of the Marquette and Menominee iron-ore districts have usually been given together, but the districts are not contiguous. In a list of eighty-two mines in the two districts, which we find credited in the Marquette *Mining Journal* with having produced iron ore in one or all of the last three years, fourteen are located in the Menominee district. The production of iron ore in 1884 in these two districts and by the isolated Colby mine, in Ontonagon county, also in upper Michigan, was 2,455,924 gross tons, of which the Menominee district produced 698,047 tons. In 1882, however, the two districts alone produced the exceptionally large quantity of 2,947,392 tons, and in that year the proportion of the Menominee district was 1,032,611 tons. The most productive mine in the whole Lake Superior region in 1883 and 1884 was the Chapin mine, in the Menominee district, which produced 265,830 tons in 1883 and 290,972 tons in 1884. The Lake Superior mine, in the Marquette district, has, however, produced a still larger annual product, its output in 1882 being 296,509 tons. This latter mine has been the most productive of all the mines in the Lake Superior region, the Cleveland, Jackson, and Republic mines, in the same district, coming next in the order mentioned.

Since 1856 the total production of iron ore on the southern shore of Lake Superior has amounted to 24,809,391 gross tons. Most of the capital that has been invested in the development of the iron ores of this region has been supplied by New England, New York, Pennsylvania, and Ohio.

4. The Vermillion Lake iron district, in Saint Louis County, Minnesota, on the northern shore of Lake Superior, embraces several extensive mines that are opened or exposed, the most of them containing hard hematite ores of the same general characteristics as those found on the southern shore of the lake. The first shipment of iron ore from this district took place on the 31st of July, 1884, over the Duluth and Iron Range Railroad, which connects Two Harbors, on Lake Superior, 25 miles northeast of Duluth, with the town of Tower, at the mines, the distance between the two places being 72 miles. This road, which is under the control of the Minnesota Iron Company, the owner of all the mines, is to be continued from Two Harbors to Duluth, where it will connect with the railroad system of the United States. At Two Harbors are extensive piers at which vessels will receive the ore, which it is expected will find its principal markets at ports on the lower lakes. The shipments in 1884, all to these ports, amounted to 62,124 gross tons. Shipments will be largely increased in 1885. Of the vast extent and uniformly good quality of the iron ores of this district there is no room for doubt, and the facilities for shipment are favorable. The policy of the company will be to ship only the best ores. All of the Vermillion Lake ores are sufficiently low in phosphorus for Bessemer purposes, but they contain little or no manganese.

The existence of iron ore in this district was discovered by explorers about twenty years ago, but it was not until 1874 that any steps were taken to ascertain their extent or value, and not until 1883 that the building of the railroad was commenced. A few of the mines were opened in 1881 and 1882. The development of this district is in the hands of experienced capitalists, at the head of whom is Mr. Charlemagne Tower, of Philadelphia.

The following analyses, made by Messrs. Carnegie Brothers & Company (limited), of Pittsburgh, present a fair average of a large number which have been made of average samples from the Vermillion mines.

The analyses here given are of ores from the mines which supplied the shipments in 1884:

Constituents.	Breitung mine.	Stone mine.	Lee mine.
Iron	69.700	69.160	67.180
Manganese	.....	trace	.....
Phosphorus	.047	.053	.050
Sulphur	.007	.008	.025
Silica	.700	.700	2.150
Alumina	.....	.400	1.230
Lime	.350	.....	.450
Magnesia	trace	trace	.320

It is a fact of much interest that Minnesota, one of our prairie States, should promise to become a large producer of iron ore.

5. In the vicinity of Gogebic Lake, in Ontonagon County, Michigan, on the southern shore of Lake Superior, and west of the Marquette and Menominee iron-ore districts, are extensive deposits of iron ore of the same general characteristics as the ores found in all the other Lake Superior districts. The existence of marketable iron ore in this district was discovered in 1880, but owing to the absence of railroad transportation no attempt was made until quite recently to develop any of the deposits, which are numerous and extensive, and are in the hands of various projectors and operators, principally under leases from the Lake Superior Ship Canal, Railway, and Iron Company. About twenty openings have been made, but down to the close of 1884 shipments of ore had been made from only the Colby mine, lying about 6 miles east of the Montreal River. It is claimed that the existence of extensive forests of hard wood in close proximity to the iron-ore deposits and to calcareous marl as a fluxing material justifies the erection of blast furnaces in the district. Analyses of numerous samples of marl found in the district show the deposits to consist of nearly pure carbonate of lime with but a trace of phosphorus.

The Milwaukee, Lake Shore and Western Railway was completed to the Gogebic district in 1884, and during 1885 it is expected that it will be completed to Ashland, Wis., on Lake Superior, where there is an excellent harbor and where expensive piers are being built, and from which it is expected that considerable shipments of iron ore to lower lake ports will be made before this year closes. It was over this road that the ore from the Colby mine was shipped by way of Milwaukee in 1884. The quantity shipped amounted to 1,022 gross tons. It was received by Carnegie Brothers & Company (limited), of Pittsburgh, for use in their blast furnaces, and gave complete satisfaction. It contained a large percentage of manganese. From the Colby mine to Ashland the distance by railroad will be less than fifty miles, and from any of the mines in the vicinity of Gogebic Lake to Ashland the distance will probably not exceed 75 miles.

In Ashland County, Wisconsin, just west of the Montreal River, which forms the boundary between Michigan and Wisconsin, are several promising iron-ore deposits which await development.

Analyses of the iron ores of the Gogebic district show that they are rich in metallic iron, very low in phosphorus, variable in silica, and free from sulphur. They are as a rule adapted to the manufacture of Bessemer pig-iron. In a few mines manganese is also found in sufficient quantity in combination with iron to produce spiegeleisen. We subjoin a few analyses of ore from the Colby mine.

Constituents.	1.	2.	3.	4.	5.
Iron and manganese	60.040	62.840	62.760	66.020	61.270
Metallic iron	48.630	55.490	57.140	65.100	52.700
Phosphorus	.063	.070	.071	.042	.075
Silica	6.080	2.680	3.690	8.840	1.820
Manganese	11.410	6.850	5.620	.920	8.570

Most of the analyses of the iron ores of this district that have been made show metallic iron ranging from 50 to 66 per cent.

6. There are four distinct iron-ore fields in Missouri, known as the Iron Mountain, the Southeastern, the Southwest, and the Western districts. "The Iron Mountain region," to quote the words of Mr. W. B. Potter, "although much the smallest in area, is by far the most important, since it has produced, and still is capable of producing, more ore than all the other regions combined." This district is located in Iron and Saint François Counties, from 80 to 90 miles south of Saint Louis. The principal deposits of the district are known as Iron Mountain and Pilot Knob. The former has been worked since 1845 and the latter since 1847. They have frequently been described. Iron Mountain alone has produced about 3,000,000 tons of ore; Pilot Knob has produced about 1,000,000 tons. In 1872 there were mined and shipped from Iron Mountain alone 269,480 tons. A large part of the production of Iron Mountain and Pilot Knob has been taken to Pittsburgh and other places on the Ohio River, but in recent years shipments have been mainly to nearer localities. Below are two analyses of Iron Mountain ore, which we take from a paper prepared by Mr. W. B. Potter in 1884, and published in the Journal of the United States Association of Charcoal Iron-workers.

Constituents.	Surface ore.	Bluff ore.
Peroxide of iron	95.040	90.610
Protoxide of iron	2.570	2.800
Silica	1.570	3.750
Alumina	.790	2.160
Lime	.170	.480
Magnesia	.140	.320
Manganese	None.	Trace.
Sulphur	.005	Trace.
Phosphoric acid	.071	.075
	100.356	100.195
Metallic iron	68.530	65.610
Phosphorus	.031	.033

The following analyses show the chemical composition of the iron ores of Pilot Knob:

Constituents.	Surface ore.	Bluff ore.
Peroxide of iron	84.330	90.870
Protoxide of iron	0.150	1.670
Silica	13.270	5.180
Alumina	2.190	.890
Lime	.210	1.760
Magnesia	.140	.130
Manganese	None.	None.
Sulphur	Trace.	.078
Phosphoric acid	0.085	.069
	100.325	100.647
Metallic iron	59.150	64.9100
Phosphorus	.015	.0031

A statement which we have received from the Iron Mountain Company gives the average analysis of a series of samples of No. 1 ore from Iron Mountain, as follows:

Constituents.	Per cent.
Metallic iron	65.5000
Silica	5.7500
Sulphur	.0160
Phosphorus	.0405

In Crawford and Dent Counties, Missouri, in the southwest section, just west of the Iron Mountain district, are numerous mines of rich ore that are operated by the Missouri Iron Company and by others. We have received from this company several analyses of the ores of this section, which show metallic iron ranging in every case above 60 per cent. with a very low percentage of phosphorus, little or no sulphur, and variable silica. We have room for only one of these analyses, relating to the surface ore of Simmons Mountain.

Constituents.	Per cent.
Peroxide of iron	98.140
Silicic acid	1.410
Alumina	.060
Lime	.240
Magnesia	.110
Phosphoric acid	.038
	99.998
Metallic iron	68.690
Phosphorus	.016

7. The immense Cornwall iron-ore deposit in Lebanon County, Pennsylvania, appears to be no nearer exhaustion to-day than when it was first opened a hundred and fifty years ago. We give below detailed analyses of six samples of the ore of the Cornwall mines, "selected," as we are informed, "to give a general average of the quality of the ore." The mines supply a large number of local and neighboring furnaces. Pig-iron made from this ore has been largely used as a mixture with other pig-iron in the manufacture of Bessemer steel.

Constituents.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
Magnetic oxide of iron	78.278	62.198	67.282	68.965	53.075	41.131
Sesquioxide of iron	.....	.....	Trace.	22.794	.....	52.298
Oxide of copper	1.840	1.480	Trace.	0.250	1.800	0.080
Oxide of cobalt	0.200	0.095	0.158	0.067	0.076	0.105
Oxide of manganese	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.
Magnesia	1.286	2.695	1.867	1.228	3.198	1.369
Lime	1.000	1.110	1.210	1.403	1.510	1.111
Sulphuric acid	0.089	0.204	0.105	0.013	0.187	.....
Phosphoric acid	0.072	0.010	0.006	0.002	0.003	0.006
Quartz and silica	11.082	28.000	18.240	2.200	37.880	3.840
Copper pyrites	0.352	1.818	0.232	0.084	0.604	.....
Iron pyrites	5.222	1.792	8.299	.....	1.479	.....
Water, &c	0.629	0.598	2.522	2.943	0.603	2.107
	100.000	100.000	100.000	100.000	100.000	100.000
Metallic iron	59.229	46.422	52.666	65.952	39.380	64.992
Metallic copper	1.589	1.814	0.080	0.200	1.246	0.024
Phosphorus	0.032	0.004	0.002	0.007	0.001	0.002
Sulphur	2.910	1.672	4.549	0.045	1.076	.....

8. The Salisbury iron region is properly confined to the town, or township, of this name in the northwestern portion of Litchfield County, Con-

necticut, but it is frequently referred to as embracing also the contiguous counties of Columbia and Dutchess in New York and Berkshire in Massachusetts, the whole constituting a strip of country from 10 to 15 miles wide, in which may be found about twenty charcoal furnaces. The ores of this celebrated region are brown hematites, some of which are found in beds and others in veins. In the Salisbury region proper there are seven charcoal furnaces, which are supplied with ores from three mines, known as Old Hill, Davis, and Chatfield. Iron has been manufactured in this part of Connecticut since 1734. We subjoin complete analyses of the ores of the three mines mentioned, which still show no signs of exhaustion.

Constituents.	Davis.	Chatfield.	Old Hill.
Sesquioxide of iron	75.720	78.136	73.51
Sesquioxide of manganese	1.376	.826	.96
Silica	7.580	6.630	10.48
Sulphur	.082	.048	.07
Phosphoric acid	.032	.501	.57
Lime, magnesia, alumina, water, &c	15.210	13.857	14.41
	100.000	99.998	100.000
Metallic iron	53.000	54.696	51.45
Metallic manganese	.958	.576	.67
Sulphur	.032	.048	.07
Phosphorus	.014	.219	.25

The pig-iron produced from the Salisbury iron ores is in high repute for the manufacture of car-wheels and of rolls for rolling mills, but it is also in demand for all purposes requiring great strength and tenacity. More than a century ago there were many forges in this district which produced bar-iron of superior quality. The American Navy has been supplied with many guns made from Salisbury iron. Only the ore of the Davis mine appears to be adapted to the manufacture of steel.

9. The State of New York is very rich in iron ore, the principal deposits of which lie along its eastern border, on both banks of the Hudson River and in the neighborhood of Lake Champlain. Much of the ore is magnetic, rich in iron and low in phosphorus. In Clinton and Essex Counties, in the Champlain district, iron has been made directly from the ore in numerous charcoal forges (more properly bloomaries) since the beginning of the century, and considerable quantities of pig-iron have also been made in these and neighboring counties with anthracite coal and with charcoal. The annual production of iron ore in this district ranges from 500,000 to 600,000 tons. The quality of the iron made in this whole region is most excellent, and it enjoys a high reputation for various uses. As a rule the iron ores of this district are not adapted to the manufacture of any kind of steel, but some Bessemer pig-iron is made in the district, and some mines produce ores the blooms and billets from which have been used in the manufacture of crucible steel.

We subjoin seven analyses of the ore of one of the oldest iron-ore companies in this section, the Port Henry Iron Ore Company, whose mines are located in Essex County.

Constituents.	1.	2.	3.	4.	5.	6.	7.
Magnetic oxide of iron	88.323	88.772	76.608	81.381	85.559	84.623	92.78
Phosphoric acid	1.791	1.513	4.227	4.694	3.297	3.495	.71
Equivalent to—							
Metallic iron	63.958	64.287	55.475	58.935	61.957	61.279	67.19
Phosphorus	.782	.661	1.846	2.050	1.440	1.528	.31

10. The Chateaugay Ore and Iron Company, whose operations are on a large scale, was organized in 1881 (after the boom of 1879 and 1880) for the development of the Chateaugay mines, in the vicinity of Chateaugay Lake, in Franklin County, west of Lake Champlain, the port of shipment being Plattsburgh, on the last-named lake, with which the mines are connected by a railroad 35 miles long, owned by the company. The company owns about 75,000 acres of land. Since the commencement of operations in 1881 it has mined 752,101 tons of ore. The output was 102,626 tons in eight months of 1881, 240,377 tons in 1882, 194,704 tons in 1883, and 214,394 tons in 1884. To meet an extraordinary demand a production of 500,000 tons per annum is possible, the mines being fully equipped with powerful machinery and the ore being favorably situated. The mining plant employed by this company is one of the most extensive and complete in the country. In addition to its mining operations the company is a large producer of charcoal blooms, owning a number of forges in the neighborhood, and it also owns and operates one charcoal furnace at Plattsburgh. Much the larger portion of the ore produced by this company is, however, sold to furnace owners in New York and neighboring States, where it has been used in the manufacture of Bessemer steel and for other purposes. We subjoin an analysis of Chateaugay ore, which we obtain from the company.

Constituents.	Per cent.	Constituents.	Per cent.
Peroxide of iron	47.380	Sulphur	.084
Protoxide of iron	21.320	Silica	20.890
Protoxide of manganese	.210		
Alumina	4.020		99.791
Lime	3.720		
Magnesia	2.110	Iron	49.750
Phosphoric acid	.057	Phosphorus	.025

11. In the immediate vicinity of New York City, and near to the Hudson River, are two celebrated iron-ore fields—one known as the mines of the Sterling Iron and Railway Company, which have been worked since 1750, and the other known as the Tilly Foster mine. The Sterling mines embrace about 22,000 acres in Orange and Rockland Counties, and the Tilly Foster mine is in Putnam County. The Sterling ores are most used in the manufacture of foundry and mill pig-iron, but the ore of some of the mines is a pure Bessemer ore. The reputation of the Sterling ores was made by the Long mine, which was discovered in 1750. The "big mine" is the one that is now most worked. Its ores contain some phosphorus. The company itself operates two anthracite furnaces. We give below analyses of the ores of two of the Sterling mines:

Constituents.	Cook mine.	Scott mine.
Iron	64.24	65.47
Oxygen	24.48	24.93
Silica	7.45	4.92
Sulphur	none.	none.
Phosphorus	.184	.52
Alumina	1.13	.71
Lime	.72	1.59
Magnesia	.29	.56
Oxide of manganese	.17	.32
	98.664	99.02

The Tilly Foster ore is largely used by the Lackawanna Iron and Coal Company in the production of Bessemer pig-iron, at Scranton, Pa., and it

has also been used for the same purpose by the Bethlehem Iron Company. We subjoin an analysis of this ore which has been furnished us by the first-mentioned company:

Constituents.	Per cent.	Constituents.	Per cent.
Magnetic oxide of iron	67.41	Carbonic acid	2.30
Oxide of manganese	.30	Phosphoric acid	.05
Silica	11.75		
Alumina	3.50		100.78
Lime	2.15		
Magnesia	13.24	Metallic iron	48.82
Sulphur	.08		

Several other iron-ore deposits of similar character, which are apparently large but imperfectly developed, exist within a few miles of the Tilly Foster mine.

12. A new iron-ore field was developed in 1883 on the east side of the Hudson River, in Columbia County, by the Hudson River Ore and Iron Company, which has expended a large sum of money in prosecuting its enterprise. The ore of this district is described as a carbonate that is not greatly unlike the Cleveland ore in England, but much richer. When roasted it is adapted to the manufacture of Bessemer steel. The quantity of ore mined in 1884 by the company owning this property amounted to 90,000 tons. The deposits are very large. We subjoin two analyses of the ore after it had been roasted, which we take from The Iron Age:

Constituents.	1.	2.
Iron	51.160	50.820
Silica	9.200	9.030
Sulphur	.550	.600
Phosphorus	.029	.031

We are furnished by Messrs. Crocker Brothers, of New York, the agents of the Hudson River Ore and Iron Company, with the following more complete analysis of roasted ore:

Constituents.	Per cent.	Constituents.	Per cent.
Peroxide of iron	66.991	Silica	11.030
Protoxide of iron	3.584		
Protosesquioxide of manganese	3.066		99.690
Alumina	2.637		
Lime	3.720	Iron	49.682
Magnesia	7.125	Phosphorus	.038
Phosphoric acid	0.087	Sulphur	.530
Sulphuric acid	1.450	Manganese	2.209

13. All of the iron ores of New Jersey that are now mined are in the northern part of the State. They are chiefly magnetic. In the last century and during a considerable part of the present century bog ore was used in a number of charcoal furnaces in the southern part of the State. Most of the ores that are now mined are only suitable for forge or foundry purposes, but some are well adapted to the manufacture of Bessemer pig-iron as they come from the mine, while others contain too much sulphur for this purpose and require to be roasted. These ores are also roasted when used for other purposes. We subjoin two analyses of magnetic ores obtained in Sussex County, which are very low

in sulphur and are used at Franklin Furnace in the manufacture of Bessemer pig-iron:

Constituents.	Hill vein.	Furnace vein.
Magnetic oxide of iron	69.50	65.40
Oxide of manganese	.46	4.13
Silica	18.27	1.05
Alumina	.27	.18
Lime	5.00	9.74
Magnesia	2.73	6.44
Sulphur	.10	.45
Carbonic acid	3.55	11.93
Phosphoric acid	.03	.05
Graphite	.....	.78
	99.91	100.15
Metallic iron	50.32	47.35

A larger general average of New Jersey magnetic ores would show a higher percentage of metallic iron and would be more favorable in other proportions for special purposes. For example, the ore of the Richard mine, in Morris County, owned and operated by the Thomas Iron Company, averages 60 per cent. of metallic iron, and contains some phosphorus but no sulphur.

The present state of the iron-ore industry of New Jersey is described as follows by the State Geologist, Prof. George H. Cook, in his annual report for 1884:

The low price of iron ore and the light demand for ore at almost any figure have caused a large shrinkage in the production, and closed many of our mines. The large and increasing importations of iron ores from Spain and Africa also operate against our mines, since these rich and pure foreign ores can be put down at the furnaces near the seaboard at lower rates, per unit of metallic iron, than the New Jersey ores can be profitably mined and shipped to these same points. Besides, the adaptation of the former to the making of Bessemer iron enables them to compete successfully with our own Bessemer ores which are as yet scarcely developed. The discovery of new and productive mines along the Hudson, where ore can be obtained at a minimum of cost, also makes the competition for the Pennsylvania market sharp and telling against some of our mines where the expenses of mining are relatively larger, although our magnetic ores are richer.

14. So many varieties of iron ore are found in Ohio, and they are so widely distributed, that the State at first sight might be called rich in iron ore, and yet it annually makes more iron from Michigan ores than from the ores of its own mines. Pennsylvania, also, although celebrated as our leading iron-producing State, annually makes more iron from ores mined outside its borders than within them. A quarter of a century ago Professor Lesley wrote of Pennsylvania:

The reputation of this State for iron has resulted more from the energetic, persevering German use, for a century of years, of what ores do exist, than from any extraordinary wealth of iron of which she can boast.

In Ohio the ores of native origin are generally very lean, and too high in phosphorus to be serviceable in the manufacture of steel. Economy in the one case and necessity in the other combine to create a demand for Michigan ores, which are transported to ports on Lake Erie at comparatively slight cost, meeting the fuel to smelt them at many places in Ohio, even as far south as the Ohio River. Michigan ores are taken in large quantities to the Shenango Valley, and to Allegheny, Cambria, and other counties in Western Pennsylvania. Spanish and other foreign ores also find their way to this part of the State, and are still more largely con-

sumed in the eastern part, in both sections meeting the best of mineral fuel. Michigan and foreign ores are used in Pennsylvania because of their fitness as a mixture with native ores and their comparative cheapness, and because also of the leanness of so many of the native ores and of the phosphorus that most of them contain.

We omit analyses of the ores of Ohio and Pennsylvania as unnecessary. It must be added, however, that Ohio is a large manufacturer of rolled iron and of the best qualities of foundry iron, produced from its Hanging Rock, blackband, and other native ores, and that the bar, plate, and sheet iron of Pennsylvania and its foundry iron, made exclusively from native ores, are unexcelled anywhere. In both States charcoal is still used as fuel in many furnaces.

15. Indiana and Illinois produce so little iron ore that details may properly be omitted. The same observation may be made of all the New England States except Connecticut, which has already been noticed. Illinois is, however, one of the most prominent iron and steel producing States in the Union, but the ores it uses are mostly drawn from Lake Superior and Missouri, and the fuel for its blast furnaces is obtained mainly from the Connellsville region of Pennsylvania.

16. Delaware does not now manufacture pig-iron, although it contains some small deposits of very good ores for general purposes. Maryland is not a large manufacturer of pig-iron, but the pig-iron that it makes from its own ores is noted for its great strength and also for its adaptability to the manufacture of car-wheels. Some foreign ores are imported into this State for use as a mixture with native ores. Very little Bessemer pig-iron has been made in Maryland.

17. Iron ores are found in most parts of Virginia, and they are usually of good quality, although very few are perfectly adapted to the manufacture of Bessemer steel, and these have thus far been found mainly in small pockets. It is possible that large bodies of ore may yet be developed along the lines of the Norfolk and Western and the Shenandoah Valley Railroads, and elsewhere, which will be suitable for the manufacture of steel. In Southwestern Virgina pig-iron of a very superior quality for the manufacture of car-wheels has long been made in charcoal furnaces. In other parts of Virginia pig-iron of excellent quality is made in a few charcoal furnaces and in several new and large coke furnaces, and this iron is finding a market for general purposes as far north as New England.

Near Crimora Station, in Augusta County, Virginia, on the Shenandoah Valley Railroad, there exists a large deposit of manganese ore, which has been worked for several years and which has contributed during the past year a considerable quantity of ore for the manufacture of spiegeleisen and ferromanganese in Pennsylvania. An analysis of this ore gives 57.291 per cent. of metallic manganese, .373 of metallic iron, and .075 of phosphorus. There are other promising deposits of manganese ore in this State.

In West Virginia a great variety of iron ores is also found, which are smelted with both coke and charcoal, but few if any of these have been used in the manufacture of steel. The Bessemer steel that is now manufactured at Wheeling is made from pig-iron smelted from Lake Superior and Missouri ores. The State is more noted for its coal deposits and for the large quantities of nails it manufactures than for its iron ores.

18. An extensive deposit of magnetic iron ore is found on the western slope of Iron Mountain, in Mitchell County, North Carolina, about 3 miles from the Tennessee line, which is known as the Cranberry "ore

bank." This deposit has been worked in a small way for a hundred years, the ore being converted into bar iron in the neighboring bloomaries, but recently the Cranberry Iron Company has made preparations to ship the ore to other sections of the country, and it has also built a small charcoal furnace at the mines. The distance from the mines to places of consumption is, however, so great that up to the present time but little ore has been shipped, although its superior adaptability to the manufacture of steel is everywhere acknowledged. It is practically free from sulphur and phosphorus. We subjoin five analyses of Cranberry ore, which we obtain from Mr. P. M. Hale's work on The Coal and Iron Counties of North Carolina:

Constituents.	1.	2.	3.	4.	5.
Magnetic oxide of iron	94.37	91.45	85.59	80.78	91.89
Oxide of manganese	.26	.06	.24	1.42	.32
Alumina	.42	.77	.11	.52	1.03
Lime	.43	1.01	.72	.....	1.06
Magnesia	.36	.53	.33	.....	.23
Water	.....	.44	1.53	8.21	1.15
Silica, pyroxene, &c	4.16	5.74	11.48	9.08	4.02
Sulphur	.....	.....	.....	.....	.25
Phosphoric acid	.....	.....	.....	.....	trace
	100.00	100.00	100.00	100.00	99.95
Metallic iron	68.34	66.22	61.98	58.49	66.53

North Carolina has many other deposits of magnetic and hematite ores, which have been fitfully worked in a small way for more than a century, but none of these deposits, not even the Cranberry "ore bank," will compare in extent with the immense deposits of Lake Superior, the Iron Mountain and Pilot Knob in Missouri, and the Cornwall "ore hills" in Pennsylvania. The coal deposits of North Carolina are as yet practically undeveloped.

19. The iron ores of Kentucky, Tennessee, Alabama, and Georgia embrace most known varieties, and they are certainly found in very large quantities and are widely distributed. They have been worked for many years, some of them for a hundred years, and much of the iron made from them has enjoyed a very high reputation for strength and toughness. Until in recent years charcoal was exclusively used as fuel, but now coke is largely used, chiefly in new and modern furnaces. Chattanooga and Birmingham are now as well known iron centers as Pittsburgh, Youngstown, Johnstown, or other places in the North. Southern pig-iron is shipped to Philadelphia, New York City, and to New England markets and is sold at a profit. The impetus that has recently been given to the iron industry of this section is largely due to investments of Northern capital. The four Southern States mentioned do not as a group produce any appreciable quantity of steel, and for the reason that very few ores suitable for the manufacture of steel have been discovered. Even in the vicinity of Birmingham, where there are a dozen furnaces, no attempt has yet been made to manufacture Bessemer pig-iron, because suitable ores are not within reach. Some ores, it is true, are sufficiently low in phosphorus, but they are practically unfitted for the manufacture of steel because of the very great irregularity in the occurrence of this obnoxious element. Ore has been taken from some hematite veins in Alabama that was almost free from phosphorus, but twenty yards distant in the same vein one-half of 1 per cent. of phosphorus has been found. In Georgia and Alabama several small mines of mangan-

iferous iron ore suitable for the manufacture of spiegeleisen have been opened and their product is now being utilized.

We subjoin several representative analyses of Alabama ores which we receive from an entirely trustworty source.

Constituents.	Magnetic.	Red hematite.		
		1.	2.	3.
Oxide of iron	66.05	63.87	84.58	80.64
Oxide of manganese	10.25	.23	.40	.46
Alumina	6.96	.29	3.14	.50
Lime	.....	.18	5.06	.12
Magnesia	.....	.43	1.23	.33
Silica	13.00	32.22	5.54	16.80
Phosphoric acid	1.08	1.16	.07	.88
	97.36	99.38	100.02	99.67
Metallic iron	47.83	44.71	61.240	56.45
Phosphorus	.147	.50	.030	.34

The iron ores of Tennessee have long been celebrated. Bar iron was made in its Catalan forges a hundred years ago, and fifty years ago iron was made in considerble quantities in this State and shipped to Pittsburgh in the form of blooms. Much of the capital that was then used in developing its iron-making resources was supplied by Pennsylvania iron masters. In the manufacture of car-wheels and best refined bar iron the iron ores of Tennessee have no superior. As one result of the extension of the railroad system of the State it is supposed that larger deposits of iron ore than have ever been worked within its borders will soon be developed. The iron ores of this State exist in such great variety that any analyses we might give of them in our limited space would represent only a small part of them.

The most important iron-making district in Kentucky is the Hanging Rock district, and yet this district now draws its principal supply of ore from Bath County in the same State, but outside of the district. Considerable quantities of ore from Bath County are annually sent to Ashland, Ky., and also to Ironton and Columbus, Ohio. An average analysis of the ores of Bath County is as follows:

Constituents.	Per cent.
Peroxide of iron	76.070
Alumina	2.590
Lime	.130
Magnesia	.261
Silica	8.180
Phosphoric acid	1.000
Water	12.310
	100.561
Metallic iron	48.00
Manganese	.48
Phosphorus	.70

The only reason why the Hanging Rock region draws a large part of its supply of ore from Bath County appears to be the greater richness of this ore as compared with Hanging Rock ores. The latter average about 32 per cent. of metallic iron, whereas the Bath County ore averages, as has just been shown, about 48 per cent. The requirements of modern furnace practice and the severity of competition now militate greatly in all sections against the use of lean ores. The Bath County

ores produce a soft, fluid iron, very suitable for foundry purposes. The first blast furnace in Kentucky was built in Bath County in 1791. The iron ores of other sections of Kentucky produce excellent iron for rolling-mill purposes.

20. Outside of Missouri none of the States and Territories lying west of the Mississippi River have developed an iron industry of especially significant proportions. Colorado and California have made the most progress in this direction, but even their achievements have fallen very far short of the results accomplished by many of the older States. Nearly all of the States and Territories west of the Mississippi contain iron ore, but this part of our country is too vast and too new, and transportation within its limits is too restricted, to have either called for or permitted much attention to the manufacture of iron. In the light of present developments we may safely conclude that the iron industry west of the Mississippi and outside of Missouri will be of very slow growth. The most recent and valuable discovery of iron ore in the section of country under consideration has been made in Arkansas, where ore of a character suitable for the manufacture of spiegeleisen has been found in Independence County in large quantities, and is now being used by Carnegie Brothers & Company Limited and the Cambria Iron Company.

Summary.—The foregoing bird's-eye view of the iron-ore resources of our country establishes a number of important facts. It brings freshly to mind the remoteness from points of ultimate consumption of the great Lake Superior iron-ore fields, where quantity and quality of ore are found in combinations unequaled in any other section. It shows that, widely as iron ores are distributed in this country, such of these ores as are suitable for the manufacture of steel are confined to comparatively limited areas, but that they are in abundant supply. It shows that some of the most important iron-ore deposits in the country have been developed since the boom of 1879 and 1880. It shows that foreign ores, obtained in Spain, Italy, and other countries, are yearly imported into many States to be used either alone or as a mixture with native ores, and that the reasons for this importation are, first, their excellence for special purposes, particularly the manufacture of Bessemer pig-iron and spiegeleisen, and, second, their cheapness as compared with native ores that must be transported long distances by rail. We do not, however, import annually one-fifth as much foreign ore as Great Britain, nor one-half as much as France or Belgium, and but little more than one-half as much as Germany. As has been shown, our imports of iron ore in 1884 amounted to only one-sixteenth of the total quantity of domestic iron ore consumed in that year.

If the question were asked whether this country could, if required, supply from within its own borders all of the iron ore needed in every branch of its iron and steel industries, including the manufacture of the finer kinds of crucible steel, the answer might unhesitatingly be made in the affirmative. We can make as good iron for crucible steel as the Swedes do if we would only be as painstaking as they are. We have ores in great abundance for the manufacture of Bessemer steel by the original, or acid, process, which is the only process for the manufacture of this kind of steel that now exists in this country, if we except one unsatisfactory experiment that has recently been made with the Thomas-Gilchrist, or basic, process, and one establishment for the manufacture of steel by the Clapp-Griffiths process. These ores are, however, not readily accessible to all the Bessemer establishments of the country. We have discovered ores for the manufacture of spiegel-

eisen and ferro-manganese that would place our steel industry on a self-sustaining basis if our foreign supply of these products should be interrupted. We would be better off in this particular than Great Britain, which is practically without manganiferous iron-ore deposits. Manganese itself we export to that country. The firm of Carnegie Brothers & Company (limited), of Pittsburgh, uses only domestic ore in the manufacture of its high-grade ferro-manganese.

As steel has rapidly come into use in late years as a substitute for iron, not only for rails but for other purposes, it is a fact of some interest, to which, we believe, public attention has not heretofore been called, that pig-iron suitable for the manufacture of Bessemer steel by the process that is now in use in this country has never been made in any part of the country south of the Potomac or south of Wheeling. Southern ores, with rare exceptions, are too high in phosphorus for the purpose mentioned. If the South should engage in the manufacture of Bessemer steel to a greater extent than it has yet done at Wheeling it would probably employ the Thomas-Gilchrist process, which requires that pig-iron should be high in phosphorus that the work of elimination in the converter may be completely successful; or it would employ the Clapp-Griffiths process, which is said to permit the presence in the steel itself of a large percentage of phosphorus without detriment to its quality, a result which is only rendered possible by the rigorous exclusion of silicon.

May, 1885.

JAMES M. SWANK.

STATEMENT OF MR. FREDERIC P. DEWEY.

WASHINGTON, D. C., *November* 17, 1884.

Mr. MORGAN. Please state your name and present position.

Mr. DEWEY. Frederic P. Dewey; curator metallurgy, National Museum.

Mr. MORGAN. How long have you been in the business of investigating the metallurgy of iron and steel?

Mr. DEWEY. About nine years.

Mr. MORGAN. Before that time what was your occupation?

Mr. DEWEY. I was studying before that, preparing for my investigations. I was educated at the Sheffield Scientific School at New Haven.

Mr. MORGAN. You are both a metallurgist and chemist, and now the curator of this section of the National Museum?

Mr. DEWEY. Yes, sir.

Mr. MORGAN. Where did you do your earliest work as chemist and metallurgist?

Mr. DEWEY. My first practical engagement was at the Port Oran Furnace, in Morris County, New Jersey, manufacturing mainly spiegeleisen for the steel business. I had charge of the laboratory, and, incidentally, had considerable to do with the furnace. I made a very complete record of its work. Every cast of metal was analyzed thoroughly and all ores and materials used.

Mr. MORGAN. Your next engagement was where?

Mr. DEWEY. After that I spent some time at New Haven—about a year—studying and making analyses, and then went to Chattanooga, Tenn.; was chemist to the Roane Iron Company, and had charge of the steel-melting house there.

Mr. MORGAN. Are there any ores abundant in New Jersey that would make Bessemer steel without mixing with other ores?

Mr. DEWEY. Yes, sir; the ore with which I was most familiar was the Hedges, at Chester, in Morris County.

Mr. MORGAN. What is the average percentage of metallic iron in those ores?

Mr. DEWEY. In the Hedges ore it was about sixty. That ore, however, was high in sulphur and required roasting.

Mr. MORGAN. Could you free the ore from sulphur by roasting?

Mr. DEWEY. Yes, sir; to a large extent.

Mr. MORGAN. And in that way you made it a good steel ore?

Mr. DEWEY. Yes, sir; the sulphur in the original ore is very high—over 2 per cent.—and they run it down as low as 0.1, with an average of about 0.25.

Mr. MORGAN. In your experience in handling iron ores that are highly charged with sulphur, is it practicable, generally, to get rid of the excessive percentage by roasting?

Mr. DEWEY. That depends a great deal upon the character of the sulphur. If the sulphur is present as iron pyrites, it is very easy to remove it; if it should be present as the white-iron pyrites—the magnetic

pyrites—it is not so easy. The iron pyrites is a compound of 1 equivalent of iron and 2 equivalents of sulphur; it is exceedingly easy to drive off the first atom of sulphur, while the second atom goes off slowly but surely. In the magnetic pyrites, the compound is 7 equivalents of iron to 8 equivalents of sulphur. There is only a small amount of the sulphur that goes out easily, but the rest of it roasts off in contact with the air in a heated condition. If, however, the sulphur is present in an oxidized state, as a sulphate, as is quite frequently the case, no amount of roasting will take it out. There is a specimen [exhibiting] containing gypsum—sulphate of lime—and no amount of roasting will take that sulphur out. On the other hand, sulphur in that condition goes off more easily in the slag in the blast furnace than it does in the form of pyrites. Much of the sulphur in the Hedges ore is in the form of magnetic pyrites.

Mr. MORGAN. Is it a fact that the magnetic ores are generally charged with a less amount of sulphur than the hematites?

Mr. DEWEY. No; the magnetites as a rule contain more sulphur than any other ore.

Mr. MORGAN. And harder to get rid of if in the oxidized form?

Mr. DEWEY. It is not often in the oxidized form in the magnetites, but when it is, it is harder to get rid of.

Mr. MORGAN. What would you say would be the supply of steel-producing ores in New Jersey that would yield as much as 50 per cent. of metallic iron; whether the supply would be adequate, for example, for the prospective uses of the Government in building ships and guns?

Mr. DEWEY. Undoubtedly, the supply would be adequate.

Mr. MORGAN. Did you make spiegeleisen in New Jersey of native ores?

Mr. DEWEY. Principally of foreign ores. Towards the latter part of the time that I was there an attempt was made to utilize the residuum from the Franklinite ore. This ore contains zinc, iron, and manganese. The zinc is first taken out in the ordinary Wetherill furnace by distillation and oxidation, leaving a residue containing iron and manganese. This is called "residuum." They attempted at this furnace to use that residuum in the manufacture of spiegeleisen. They met, however, with two difficulties; the process of extracting the zinc is also the process of forming a silicate, and that silicate was troublesome in the furnace on account of giving up its silicon easily to the pig. But the great trouble was with the zinc remaining in the residuum. The zinc process did not take out all of the metal. Sometimes two or three per cent. would remain, and this zinc would go off in the blast furnace and form a crust around the tunnel-head, besides going over into the gas ways and choking them up, necessitating long and disastrous stops to clean them out.

Mr. MORGAN. Have you ever made any spiegeleisen in the United States from native ores?

Mr. DEWEY. None but that.

Mr. MORGAN. Did you ever make any examination of the spiegeleisen ores in the vicinity of Oxford, Ala.?

Mr. DEWEY. No, sir; but I have analyzed quantities of manganese ores from all over Georgia, and some from Alabama.

Mr. MORGAN. Are they abundant in Georgia and Alabama?

Mr. DEWEY. Very abundant; but the ores there are generally rather high in phosphorus.

Mr. MORGAN. You speak now of manganese ores proper?

Mr. DEWEY. Yes, sir; more particularly those about Cartersville.

At the diamond furnace near Cartersville, Ga., a considerable amount of spiegeleisen was made in 1875; this was of very good quality, and was used in the manufacture of steel. At times some high grade ferromanganse was made as high as 60 per cent. manganese. This furnace stopped making spiegeleisen before I went to Chattanooga, but I used considerable of the material produced by it.

Mr. MORGAN. Was it good?

Mr. DEWEY. It was with the one exception of being high in phosphorus. It contained from about 0.25 to 0.4 of phosphorus.

Mr. MORGAN. What would you think would be a good description of iron for making Bessemer steel? Give the different deleterious elements that might be safely combined or found in the product; and give your opinion as to what could be classed as good ore for the production of steel.

Mr. DEWEY. The first thing to consider, of course, is the phosphorus. In the Bessemer process the pig-iron to be used ought not, under ordinary circumstances, to contain over 0.1 per cent. of phosphorus. This would necessitate less than 0.05 of 1 per cent. of phosphorus in a 50 per cent. ore. If the fuel or the limestone used for flux should contain phosphorus there must necessarily be a corresponding reduction of the amount of phosphorus contained in the ore in order to make a suitable pig-iron for steel making. It is possible sometimes to use a pig-iron containing more than 0.1 per cent. of phosphorus, provided it is mixed with an iron containing so much less than 0.1 per cent. that the average in the final mixture falls below the limit of 0.1 per cent. The question of sulphur in the ore is not so easy to state, because by the use of lime in sufficient amounts quite large percentages of sulphur can be removed. I have no doubt that with proper treatment ores containing 0.4 per cent. of sulphur could be utilized for making pig-iron for the Bessemer process. Sulphur can be removed in a blast furnace, while only an exceedingly small amount of phosphorus can be removed when the furnace is running properly.

Mr. MORGAN. What amount of silicon would be admissible in iron if you expected to produce Bessemer steel?

Mr. DEWEY. The silicon might run up as high as 3 per cent.

Mr. MORGAN. Without detriment to the steel?

Mr. DEWEY. Yes, sir. It is necessary to have about 2 per cent. of silicon in the pig in order to keep up the heat during the blow.

Mr. MORGAN. Please to explain that necessity and the reason for it.

Mr. DEWEY. It is necessary to have something to keep up the heat of the bath of metal during the blow. I will not say it must be silicon, but with a charge of molten pig in the converter, it must necessarily be kept hot to keep it fluid. Now, the limit of carbon that can be obtained in an ordinary pig is not sufficient, as the combustion of that carbon will not give sufficient heat to keep the bath fluid, and silicon is the most available material for this purpose.

Mr. MORGAN. Would you think 2 per cent. of silicon would be necessary in order to keep the bath fluid and to produce a proper quality of steel?

Mr. DEWEY. No, sir; it is not necessary for the quality. If you could get the heat in some other way it would be the same. The silicon is simply the producer of heat.

Mr. MORGAN. Is that also true in the open-hearth and in the crucible process?

Mr. DEWEY. It is not; but, on the contrary, the reverse is true. In such cases you want as little silicon as possible.

Mr. MORGAN. So that in making Bessemer steel at least 2 per cent. of silicon is required, and in the crucible and open-hearth processes you think the presence of silicon would be a disadvantage?

Mr. DEWEY. Yes, sir; I not only think so, but that is a thing I know.

Mr. MORGAN. If you found that pig metal you were converting into steel had, say, 10 per cent. of silicon in it, would you feel that you were able to get rid of that at will?

Mr. DEWEY. That would depend upon two circumstances. Do you mean to limit me to that kind of iron entirely?

Mr. MORGAN. No; I mean to limit you to iron to produce steel.

Mr. DEWEY. No; but if I have an iron very high in silicon it can frequently be used by mixing with iron lower in silicon.

Mr. MORGAN. I mean to bar that out.

Mr. DEWEY. Then irons as high as 10 per cent. in silicon can be utilized by treating them by some of the various bath processes, more particularly what is called the Krupp washing process, which is essentially the same in its design as that for the removal of phosphorus. I have used it for the removal of silicon and found it to work very well. Pig iron made from a gray specular ore from near Cartersville, Ga., in the Chattanooga furnace, contained from 3 to 4½ per cent. of silicon. By treatment with oxide of iron in the ordinary puddle furnace and rabbling the silicon was reduced to about 1 per cent.

Mr. MORGAN. Do you think that heat alone, without any other agent, would be sufficient to reduce the silicon in iron excessively charged with it down to a sufficient per cent.?

Mr. DEWEY. Simply by heating?

Mr. MORGAN. Yes; continuing the boiling, for instance?

Mr. DEWEY. No, sir; it is desirable to keep the heat, in such a case as that, just as low as can be and keep the metal working. At a high temperature the silicon will be reduced and returned to metal.

Mr. MORGAN. Silicon has a strong affinity then, I suppose, for iron?

Mr. DEWEY. Yes, sir.

Mr. MORGAN. And when that is melted and the silicon is actually in a state of fusion it is apt to combine with the iron?

Mr. DEWEY. When it is reduced from its oxygen compound then it will combine with iron. You can hardly say when it is melted, because it melts at a very high temperature. You must have it in combination with iron.

Mr. MORGAN. It becomes a metal, then, when it is reduced?

Mr. DEWEY. Yes, sir; metallic silicon.

Mr. MORGAN. You would not regard the presence of an excess of silica in the ore as necessarily preventing the use of that ore for making good steel?

Mr. DEWEY. No, sir; that would not prevent its making good steel. Of course, when I say "prevent" I mean what I say. I do not mean that it might not be more desirable to use an ore that was low if you could get it.

Mr. MORGAN. In your examination of ores of the South have you ever found any titanic acid?

Mr. DEWEY. No, sir.

Mr. MORGAN. Any alumina?

Mr. DEWEY. Yes, sir; alumina is almost always present in iron ores.

Mr. MORGAN. Are "limonites" and "hematites" convertible terms?

Mr. DEWEY. Hematite is the anhydrous oxide of iron, while limonite is the hydrated oxide. Hematite is red, limonite is brown. In the terms of the miner they are frequently convertible.

Mr. MORGAN. The magnetic ores are gray, are they not?

Mr. DEWEY. They are generally black.

Mr. MORGAN. I supposed they were gray because they appear gray in combination.

Mr. DEWEY. Yes, sir. When the black magnetic oxide of iron is mixed with a white material like quartz the ore would appear gray.

Mr. MORGAN. In your examinations in the South have you found a greater prevalence of phosphorus in the limonites or in the magnetic ores?

Mr. DEWEY. As a general thing there has been more phosphorus in the limonites than in the magnetic ores; but, at the same time, I have examined more limonites than I have magnetites.

Mr. MORGAN. Will you give some account of the limonites?

Mr. DEWEY. Beginning even farther north than the out-crops marked upon the maps of Carter County, deposits of limonite sufficiently low in phosphorus for Bessemer purposes have been discovered. The following analyses are of ores from Taylor's Ridge, Carter County, Tennessee:

No. 1. Phosphorus, 0.075 per cent.; silicious matter, 11.35 per cent.; metallic iron, 59.05 per cent.

No. 2. Phosphorus, 0.054 per cent.; silicious matter, 16.63 per cent.; metallic iron, 62.72 per cent.

Just east of the railroad in Hamblen County, Tennessee, an ore found on Mr. Williams's farm contains 0.028 phosphorus; and on Mr. Woods's farm is an ore containing 0.059 phosphorus. Just at the beginning of the line of outcrops marked upon the map is an ore suitable for the Bessemer process. A sample of the ore from Bompas Cove, south of the town of Morristown, yielded the following results upon analyses by Professor C. F. Chandler, September 28, 1872:

	Per cent.
Sesquioxide of iron	81.35
Sesquioxide of manganese	0.75
Alumina	1.59
Lime	0.57
Magnesia	0.12
Sulphur	0.16
Phosphoric acid	0.11
Silica	11.74
Water	3.80
	100.19
Equivalent to—	
Metallic iron	56.19
Metallic manganese	0.52
Sulphur	0.16
Phosphorus	0.05

Following along the line of outcrops, the next place explored is just south of the town of Maryville. This locality is the most thoroughly developed of any in this region. A considerable amount of ore has been taken out for use at Chattanooga in the manufacture of steel in open-hearth furnaces. The following series of analyses was made by myself while at Chattanooga:

Constituents.	Seaton.	Wilson.	Stockpile at Chattanooga furnace.	Mary Carpenter.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*
Water	11.33	13.00	.....	12.02
Silica	4.23	4.00	5.60	.....
Iron	57.68	57.04	55.16	58.20
Sulphur	0.79	0.46	0.14	.....
Phosphorus	0.05	0.042	0.044	0.033

	Per cent.
Phosphorus:	
Widow Carpenter	0.047
Woods-Wilson	0.097
Do	0.066
E. Carpenter	0.031
Three miles south of Maryville	0.045
Pope	0.071
Rorex	0.044
Seaton	0.075
Montgomery	0.049
Mary Carpenter	0.030
Do	0.018
Silica:	
Seaton	2.54
Montgomery	5.49
Mary Carpenter	4.64
Do	4.04

Following along the same line to the Tellico River, in Monroe County, I have made the following analyses: Phosphorus, 0.032 per cent.; 0.050 per cent.; 0.031 per cent.

Continuing along the line east of Athens, in the same county, I have made the following analyses: Phosphorus, 0.013 per cent.; 0.060 per cent.; 0.049 per cent.

At the end of the line at Hiwassee, in McMinn County, I have made the following analyses: Phosphorus, 0.058 per cent.; 0.063 per cent.; 0.031 per cent.

Mr. MORGAN. Are all the ores above described limonites?

Mr. DEWEY. Yes, sir.

Mr. MORGAN. Have you tested any ores practically as well as chemically in Georgia and Alabama, amongst the limonites?

Mr. DEWEY. Not any of the limonites.

Mr. MORGAN. Will you give a history of the Maryville ores?

Mr. DEWEY. The ores were mined by the Roane Iron Company and smelted by the Chattanooga Iron Company; and the pig was delivered to the Roane Iron Company at their steel furnace and converted into steel in the open-hearth plant. The same ores were afterwards sent to Rockwood, Tenn., and smelted by the Roane Iron Company, and returned to Chattanooga and manufactured into steel by the open-hearth process for rails.

Mr. MORGAN. Did they make good rails?

Mr. DEWEY. They made very good rails. The rails were sold to and used by various railroad companies in the South. They sold all they could make.

Mr. MORGAN. Have you ever examined the Cranberry ores of North Carolina?

Mr. DEWEY. I have been to the Cranberry mine; have made a hurried examination of it, and have seen considerable of the Cranberry ore and known it by reputation for eight years.

Mr. MORGAN. What appeared to be the quantity of supply at the mines?

Mr. DEWEY. The supply of what might be called first-class shipping ore that would bear transportation to Pennsylvania, seemed to be somewhat limited, but the supply of good smelting ore that could be utilized within a reasonable distance of the furnace was quite large.

Mr. MORGAN. Utilized for steel?

Mr. DEWEY. Utilized for the manufacture of pig-iron to be converted into steel. In the case of the Cranberry, I should think it would be better to have the pig smelted somewhere near the mine, say at Knoxville or Chattanooga. If the steel works were located at the same

place very well, but if they were located farther away it would be more economical to smelt the ore and then transport the pig.

Mr. MORGAN. Have you an analysis of the Cranberry ore?

Mr. DEWEY. I have never analyzed it.

Mr. MORGAN. What is the reputation of that ore for steel producing?

Mr. DEWEY. Its reputation is very high as a steel ore.

Mr. MORGAN. Is it in reach of railroad transportation?

Mr. DEWEY. There is a railroad to it now from Johnson City, on the line of the East Tennessee, Virginia and Georgia Railroad. It is a narrow-gauge railroad owned and operated by the company owning the mines.

Mr. MORGAN. The Cranberry ore is magnetic?

Mr. DEWEY. Yes, sir.

Mr. MORGAN. What is its color?

Mr. DEWEY. Dark and greenish-black. There is considerable green hornblende in it.

Mr. MORGAN. Are there outcrops of magnetic ores from the Cranberry mines running in a southwesterly direction in the neighborhood of the North Carolina line?

Mr. DEWEY. Yes, sir. You can begin in North Carolina very near the Virginia line and find a series of outcrops there running along down sometimes on one side of the boundary and sometimes on the other between North Carolina and Tennessee until you get down into Georgia.

Mr. MORGAN. I suppose that this iron belt keeps along with the ranges of mountains that form the western border of North Carolina?

Mr. DEWEY. Yes, sir.

Mr. MORGAN. Those mountains are drained on the west side into the Tennessee River?

Mr. DEWEY. Yes, sir.

Mr. MORGAN. Are the ores abundant through that region of country?

Mr. DEWEY. The only place that I personally examined is at Cranberry, but the whole country there has the reputation of containing a great many large bodies of magnetic ore.

Mr. MORGAN. If the other ores to the southwest of Cranberry are equal in quality with those beds, then you would say that the supply of steel-producing magnetic ore from that region of country would be without limit?

Mr. DEWEY. Yes, sir; practically without limit.

Mr. MORGAN. Are the Ashe County ores also magnetic?

Mr. DEWEY. Yes, sir.

Mr. MORGAN. Give any description that you have of those ores.

Mr. DEWEY. Magnetic from Ashe County, North Carolina, shows the following:

	Per cent.
Silica	13.88
Iron	53.68
Titantic acid	.00
Phosphorus	0.026
Sulphur	0.092

December 22, 1879.

Mr. MORGAN. That is on the Atlantic slope?

Mr. DEWEY. Yes, sir; that is not so available. There are said to be very large bodies of ore in Ashe County and vicinity.

Mr. MORGAN. What fuel did you use chiefly at Chattanooga in making steel?

Mr. DEWEY. In the steel furnace the coal from Coal Creek, Tennessee, was used. This was a coal very high in volatile matter.

Mr. MORGAN. Where is Rockwood?

Mr. DEWEY. It is in Roane County, Tennessee, just back of the Tennessee River, on the Cincinnati Southern Railroad.

Mr. MORGAN. If you have an analysis of that coal, please give it.

Mr. DEWEY. Coal Creek coal shows the following:

	Per cent.
Moisture	1.29
Volatile matter	34.86
Fixed carbon	58.41
Ash	5.44
Total	100.00

Color of ash, pinkish; November 22, 1879.

Mr. MORGAN. Can you give any further analyses of coals from that region?

Mr. DEWEY. I made the following analyses:

Sewanee coal, the coke of which was used at the Chattanooga furnace:

	Per cent.
Moisture	1.77
Volatile matter	25.41
Fixed carbon	62.00
Ash	10.82
Total	100.00

Sulphur, 0.648 per cent.; color of ash, pinkish; November 25, 1879.

Rockwood coal, the coke of which is used at the Rockwood furnace:

	Per cent.
Moisture	1.75
Volatile matter	26.62
Fixed carbon	60.41
Ash	11.52
Total	100.00

Sulphur, 1.487 per cent.; color of ash, pinkish; December 2, 1879.

Mr. MORGAN. In your examination of other coals in the vicinity of Chattanooga you found that they were available for furnace purposes in making steel?

Mr. DEWEY. Yes, sir.

Mr. MORGAN. Would you say that in regard to all of them?

Mr. DEWEY. Yes, sir. The next coal is the Ætna coal:

	Per cent.
Moisture	0.94
Volatile matter	23.72
Fixed carbon	63.94
Ash	11.40
Total	100.00

Color of ash, light gray; November 22, 1879.

Dade coal, Georgia:

	Per cent.
Moisture	1.29
Volatile matter	23.05
Fixed carbon	60.50
Ash	15.16
Total	100.00

Sulphur, 0.838 per cent.; December 28, 1879.

Soddy coal, on the line of the Cincinnati Southern Railroad:

	Per cent.
Moisture	1.15
Volatile matter	27.82
Fixed carbon	64.39
Ash	6.64
Total	100.00

Sulphur, 0.501 per cent.; color of ash, pinkish; November 25, 1879.

Stanley coal, below Chattanooga, on the Tennessee River:

	Per cent.
Moisture	1.36
Volatile matter	26.67
Fixed carbon	61.76
Ash	10.21
Total	100.00

Sulphur, 0.533 per cent.; color of ash, gray; December 10, 1879.

Victoria coal, from the mines of the Southern States Coal and Iron and Land Company:

	Per cent.
Moisture	3.16
Volatile matter	31.94
Fixed carbon	54.81
Ash	10.09
Total	100.00

Sulphur, 2.386 per cent.; color of ash, faint pink; November 25, 1880.

Daisy coal, on the Cincinnati Southern Railroad:

	Per cent.
Moisture	2.74
Volatile matter	26.50
Fixed carbon	67.08
Ash	3.68
Total	100.00

Sulphur, 0.907 per cent.; color of ash, reddish; December 23, 1880.

Mr. MORGAN. Have you made any analyses of coal farther down, towards Birmingham?

Mr. DEWEY. I have one analysis of the Coosa coal which I can furnish you:

Coosa coal:

	Per cent.
Moisture	1.29
Volatile matter	28.87
Fixed carbon	67.01
Ash	2.83
Total	100.00

Sulphur, 0.62 per cent.; phosphorus, 0.062 per cent.; February 24, 1880.

Glenmary coal, Tennessee:

	Per cent.
Moisture	1.66
Volatile matter	34.52
Fixed carbon	61.68
Ash	2.14
Total	100.00

Sulphur, 0.881 per cent.; phosphorus, 0.019 per cent.; color of ash, faint pinkish; August 20, 1880.

Helenwood Colliery, Tennessee:

	Per cent.
Moisture	1.83
Volatile matter	41.29
Fixed carbon	54.24
Ash	2.64
Total	100.00

June 16, 1881.

Mr. MORGAN. In the Siemens furnace, what proportion of the fixed carbon is converted into heat?

Mr. DEWEY. All of it except a very small percentage—1 or 2 per cent., which remains in the ash.

Mr. MORGAN. The volatile matter is of course converted into heat?

Mr. DEWEY. The idea of the Siemens gas producer is to convert the fixed carbon into carbonic oxide, and have it go off and mix with the hydro-carbon and give a mixed gas. The volatile hydro-carbons will go off in the top of the producer, while the fixed carbon will become oxidyzed to carbonic oxide as it descends to the grate bars.

Mr. MORGAN. In the Siemens open-hearth furnace, is the coal better that yields a large amount of volatile matter, or that which yields a lage amount of fixed carbon?

Mr. DEWEY. A large amount of volatile matter will give a gas with higher heating power.

Mr. MORGAN. And therefore it would be better?

Mr. DEWEY. Yes, sir; other things being equal, of course.

Mr. MORGAN. You give the amount of phosphorus in only a few of these coals. Did you ever find any in any of the other Southern coals that you have analyzed or used?

Mr. DEWEY. Yes, sir; in several. In the coal from Soddy I found phosphorus, 0.025 per cent. In the coke made from the Sewanee coal, used at the Chattanooga furnace, I found phosphorus, 0.079 per cent. In the coke made from the coal used at Rockwood I found phosphorus, 0.049 per cent.; 0.074 per cent. in a second sample; and in the slate of Rockwood coal I found phosphorus, 0.416 per cent.

Mr. MORGAN. That would show that the slate had been absorbing it?

Mr. DEWEY. That would indicate that the source of the phosphorus was in the slate.

Mr. MORGAN. Do you think so?

Mr. DEWEY. Yes, sir. It is pretty thoroughly established that the general source of the sulphur is in the slate—the home of it really. These determinations of phosphorus in the Rockwood coke were made with a view to determine whether the coke would be improved as regards phosphorus by washing, and I think they clearly indicate that it would.

Mr. MORGAN. Washing in water?

Mr. DEWEY. Yes, sir; it is the ordinary coal-washing process, which is simply to remove slate.

Mr. MORGAN. In the making of coke would you expect to get rid of any percentage of phosphorus found in it?

Mr. DEWEY. None at all.

Mr. MORGAN. So in making iron from coke that contained phosphorus would you expect the coke to give up its phosphorus to the iron?

Mr. DEWEY. Yes, sir. The general principle is pretty well established that whatever phosphorus goes into the furnace comes out in the iron.

Mr. MORGAN. Have you made any examination of the limestones that were used at Chattanooga?

Mr. DEWEY. I made two examinations of limestone there with two different objects in view. The first was to determine the amount of magnesia present in them. Would you like to have that?

Mr. MORGAN. Yes. Please to give it.

Mr. DEWEY. The first is a series of limestones occurring on the banks of the Tennessee River just above Chattanooga. They showed carbonate of magnesia, 10.62, 26.12, 14.35 per cent.

A series of examinations for phosphorus in limestone used at Rockwood showed the following amounts:

Phosphorus	0.015
"	0.013
"	0.011
"	trace.
"	trace.
"	0.013
"	0.009
"	0.024
"	0.008
"	0.011
"	slight trace.
"	trace.
"	0.008

Mr. MORGAN. Are the coals that you have mentioned above free from phosphorus, except those that you have designated?

Mr. DEWEY. I have made no examination of them; I cannot say. The inference would be that they would contain some phosphorus.

Mr. MORGAN. Did you examine any coals there that were entirely free from phosphorus?

Mr. DEWEY. I did not.

Mr. MORGAN. You have examined limestones that were entirely free?

Mr. DEWEY. Limestones I found entirely free from phosphorus.

Mr. MORGAN. Taking all the facts together that have come under your observation, would you say that a steel furnace at Chattanooga, supplied with ample capital and plant properly constructed, and with a good market would likely be a commercial success?

Mr. DEWEY. It could hardly be so under the present conditions.

Mr. MORGAN. You mean that the haul would be so great?

Mr. DEWEY. What I mean—is this: That the source of the ore, take first the magnetic ores, those that are positively developed so that we know anything about them—is rather too far away from Chattanooga. The other ores which I have mentioned are really not what could be called developed. I have no means of saying how much could be mined. In saying this, of course, I mean in regard to the hauling, that they cannot compete with other concerns already started, with their source of supply well determined and under control.

Mr. MORGAN. You mean, then, that they cannot compete with an uncertain market, a merely commercial market?

Mr. DEWEY. Yes, sir; they cannot do it. I mean that they cannot compete with rails at Pittsburgh at $28 a ton.

Mr. MORGAN. Now, do you think that a steel plant established at Chattanooga, if there was sufficient capital and other necessary appliances, would be able to furnish to the Government of the United States a sufficiency of steel for making ships, engines, and guns of high power?

Mr. DEWEY. Yes, sir. It could be done if it were properly encouraged.

Mr. MORGAN. Of course that question does not have any reference

to the cost of the steel when produced, but it is only a question as to the capability of the country to furnish the material?

Mr. DEWEY. It certainly can be done.

Mr. MORGAN. I believe you have stated that your examination of ores and coals and fluxes did not extend into the State of Alabama, except in one instance, at Coosa?

Mr. DEWEY. The Coosa coal in Alabama.

Mr. MORGAN. How did you find that?

Mr. DEWEY. That is very good coal, excellent coal. I have made an analysis of coke that was produced near Birmingham, Ala., as follows:

	Per cent.
Volatile matter	.16
Fixed carbon	93.01
Ash	6.83
Total	100.00
Sulphur	0.575

Color of ash, reddish.

Mr. MORGAN. You say that is very good coke?

Mr. DEWEY. It is a very good coke. It is comparatively low in ash and fair in sulphur.

Mr. MORGAN. Here is an analysis made by Mr. Sjostedt:

	Per cent.
Fixed carbon	92.39
Ash	6.92
Sulphur	0.39

Would you say that was good?

Mr. DEWEY. That is very good.

Mr. MORGAN. This coke was made without washing. Here is an analysis of iron, at the Brierfield Nail Works, by Mr. Regis Chauvenet and Brother, of Saint Louis:

	Per cent.
Silicon	1.89
Phosphorus	0.197
Manganese	0.494

Would you say that that iron was suitable for making steel?

Mr. DEWEY. That would make rail steel in the open-hearth furnace, but it would not make a high grade steel.

Mr. MORGAN. The difficulty is the phosphorus?

Mr. DEWEY. Yes, sir.

Mr. MORGAN. Would the manganese be any advantage?

Mr. DEWEY. That would not amount to much one way or the other, except that it would replace so much iron.

Mr. MORGAN. I wish to ask you in relation to some California ores, the analyses of which I have here. These are ores from which they are making steel there right along.

Magnetic ore 7 miles from Folsom:

	Per cent.
Phosphoric acid	.032
Silica and insoluble matter	3.590
Oxide of iron	94.640
Sulphur	traces.
Copper	none.
Alumina, moisture, &c	1.738
Total	100.000
Metallic iron	66.250
Phosphorus	.014
Sulphur	none.

How would that do for steel ore?

Mr. DEWEY. That is first-class steel ore.

Mr. MORGAN. Do you think you ever saw an analysis that was better for steel ore?

Mr. DEWEY. No, sir; I do not think I have.

Mr. MORGAN. It is said to be "extremely pure and rich, and easily reduced."

Brown hematite 15 miles from San Francisco:

	Per cent.
Silica	11.490
Phosphoric acid	.135
Sulphuric acid	.400
Oxide of iron	55.970
Alumina, moisture, &c	32.005
Total	100.000
Metallic iron	39.18
Phosphorus	.058
Sulphur	.160

What would you say for that as a steel-producing ore?

Mr. DEWEY. That ore alone will not produce steel. It could easily be mixed with the foregoing to produce steel.

Mr. MORGAN. Here is a "magnetic ore in Sierra County"

	Per cent.
Oxide of iron	91.21
Silica, alumina, &c	8.32
Sulphuric acid	.10
Phosphoric acid	.042
Total	99.672
Metallic iron	63.63
Sulphur	.04
Phosphorus	.018

Is that a good steel ore?

Mr. DEWEY. A very good steel ore.

Mr. MORGAN. Here is another "magnetic ore in Shasta County, near railroad:"

	Per cent.
Insoluble matter, chiefly silica	1.340
Phosphoric acid	.029
Sulphuric acid	.198
Oxide of iron	94.440
Moisture	.706
Soluble alumina, &c	3.287
Total	100.000
Metallic iron	66.11
Phosphorus	.013
Sulphur	.079

What is your opinion on that ore?

Mr. DEWEY. That is very good, too.

Mr. MORGAN. He says it is "suitable for fine steel."

Mr. DEWEY. Undoubtedly. That ore is more than suitable for a high grade of steel.

Mr. MORGAN. That you call a very excellent Bessemer ore?

Mr. DEWEY. Very.

Mr. MORGAN. I will give you another:

Magnetite, at the junction of Pitt and McCloud rivers, about 13 miles from railroad:

	Per cent.
Silica	2.025
Magnetic oxide of iron	96.524
Alumina	1.362

Lime	.597
Magnesia	.242
Sulphuric acid	trace.
Phosphoric acid	.060
Total	100.810
Metallic iron	69.897
Sulphur	trace.
Phosphorus	.026

Mr. DEWEY. That is good, too.

Mr. MORGAN. Is that very fine ore?

Mr. DEWEY. It is very nearly as fine as the other; not quite so fine as the last one, but very good steel ore.

Mr. MORGAN. I will give you another:

Magnetite, on line of Central Pacific Railroad, near Pilot Hill, 12 miles from Auburn:

	Per cent.
Silica	3.950
Magnetic oxide of iron	94.411
Oxide of manganese	none.
Alumina	1.041
Lime	.588
Magnesia	.255
Sulphuric acid	trace.
Phosphoric acid	.067
Total	100.312
Metallic iron	68.367
Sulphur	none.
Phosphorus	.029

Mr. DEWEY. That is a good steel ore, also.

Mr. MORGAN. He marks it "a high grade of ore and suitable for making the finest steel." If these ores exist in sufficient quantities then you would say, I suppose, that California rather excelled in the supply of steel ores?

Mr. DEWEY. If the quantity is abundant, certainly so. The quality is excellent indeed.

Mr. MORGAN. I will ask you whether it does not require a higher grade of ore to make Bessemer steel with safety than it does open-hearth or crucible steel as a rule?

Mr. DEWEY. Yes, sir.

Mr. MORGAN. So that in speaking of Bessemer ores you apply to them really the highest test?

Mr. DEWEY. In speaking of Bessemer ores I mean ores carrying 50 per cent. of iron with 0.05 per cent. or less of phosphorus.

Mr. MORGAN. And in a metal product about 0.1 per cent. of phosphorus?

Mr. DEWEY. Yes, sir; about one-tenth.

Mr. MORGAN. In making pig-iron for the open-hearth process is it possible to use a mixture of ores highly charged with phosphorus and still make good steel?

Mr. DEWEY. Yes, sir.

Mr. MORGAN. Please to state your experience in the removal of phosphorus from the pig by such processes as you have used.

Mr. DEWEY. The process that was used at Chattanooga for the removal of phosphorus from pig-iron, previous to its use in the open-hearth furnace, in order to make a pig high in phosphorus suitable for steel making, was what is now known as the Krupp washing process, which

consists in washing pig-iron in a bath of molten iron ore. Experiments were commenced in Chattanooga by my predecessor previous to the application for a patent in this country upon the Krupp process, but they were not carried far enough to warrant the application for a patent by him. In these experiments an ordinary puddle furnace, such as is used in the manufacture of wrought iron, was used. The bottom of the furnace was prepared by being coated with a layer of the most refractory iron ore obtainable (Iron Mountain, Missouri, ore). The pig-iron, previously melted in a cupola, was then run into this furnace and rich iron ore thrown in upon it from a shovel. The bath of iron was then worked with a rabble. The rabbling was continued as long as it was thought possible to keep the bath melted; that is, just as long as it was possible to keep the iron in the furnace and not have it "come to nature." Experiments carried on by Mr. Caldwell yielded the following results:

Pig iron containing 0.23 of phosphorus produced a refined metal with 0.03 phosphorus; pig-iron containing 0.9 of phosphorus gave a refined metal with 0.20; pig-iron containing 0.90 of phosphorus gave a wrought-iron with 0.027 of phosphorus; showing a reduction from 0.90 to 0.03; pig-iron containing 0.88 gave a refined metal with 0.18 per cent. These results were very satisfactory.

Mr. MORGAN. What ores were used in this treatment?

Mr. DEWEY. I think the ore was the ordinary fossil ore of the region; the ore itself carrying about 0.5 per cent. of phosphorus.

Mr. MORGAN. That is pretty high, is it not?

Mr. DEWEY. That is about the average of the fossil ores; from 0.4 to 0.5.

Mr. MORGAN. What further experiments were made in this direction?

Mr. DEWEY. After I went to Chattanooga this same process was carried on, but with a different character of pig. The company had on hand some 1,200 or 1,500 tons of pig carrying about from 0.27 to 0.35 of phosphorus, and from 3 to 4.5 per cent of silicon. On attempting to refine this metal by the same process it was found that the excess of silicon greatly interfered with the removal of phosphorus. Nevertheless, a small amount of phosphorus was removed in every instance. The silicon was generally brought down to about 1 per cent., and the phosphorus to less than 0.2 per cent. Other experiments tried upon the ordinary pig-iron of the region showed an elimination of phosphorus amounting in some instances to 90 per cent. of the phosphorus originally present. This process has since been developed at the Krupp works and is carried on very successfully there.

Mr. MORGAN. Give some description of the Krupp process.

Mr. DEWEY. The development of this process at the Krupp works has been under the charge of Messrs. Bender & Narges, and after a long series of experiments they describe the essentials of the process as follows: The furnace used is a Pernot revolving hearth supplied with regenerative gas chambers. The bottom and sides of the hearth are lined with the most refractory iron ore obtainable, varying in thickness from 9 to 13 inches. The bottom is made up by roughly fitting the lumps together and filling in the spaces with fine ore, which is afterwards melted and completely cements the lumps. About 20 per cent. in weight of the pig-iron charge of rich iron ore is required to repair the furnace after a charge has been run through. It is regarded as necessary that the pig-iron used should contain at least 0.3 per cent. of manganese, while 1 per cent. is regarded as preferable. Carbon should be as high as possible, from 2.5 to 3 per cent. Silicon should be as low as possible, high silicon necessitating the addition of

lime for its removal. For steel purposes pig-irons containing from 0.7 to 0.8 per cent. of phosphorus are generally used, the phosphorus being reduced to from 0.1 to 0.15 per cent. The pig-iron is melted in a cupola and run into the hearth, which is then revolved about eleven turns per minute, and in about five to ten minutes the washing is concluded. Phœnix pig, containing 0.74 per cent. of phosphorus, was reduced in seven minutes' washing to 0.106. Eleven thousand pounds of this refined metal mixed with 1,650 pounds of steel turnings, and 198 pounds of 50 per cent. ferromanganese gave a steel plate showing:

	Per cent.
Carbon	0.10
Silicon	0.025
Phosphorus	0.081
Sulphur	0.03
Manganese	0.194
Copper	0.11

(The copper comes from the Phœnix pig.) It had a tenacity of 25.87 tons lengthwise, crosswise 26.20; elongation, lengthwise, 29 to 31½ per cent.; elongation, crosswise, 25½ per cent.

Mr. MORGAN. That is about 50,000 pounds?

Mr. DEWEY. Yes, sir. Here are some more which are puddled. Ilsede pig; raw pig 2.92 phosphorus, refined pig 0.65 and 0.90; puddled bar 0.088 phosphorus. That is a puddled bar containing less than 0.1 of phosphorus from a pig containing nearly 3 per cent. That shows a great change. That, I suppose, is all that is necessary to give of that.

Mr. MORGAN. What is regarded as the essential composition aside from phosphorus?

Mr. DEWEY. In this process it has been established by the experiments at Krupp's works that the best conditions for the elimination of phosphorus are that the pig contain as small an amount of silicon as possible, from 2 to 3 per cent. of carbon and about 1 per cent. of manganese. They regard these conditions as being quite essential.

Mr. MORGAN. What becomes of the phosphorus in this process?

Mr. DEWEY. The phosphorus goes into the slag formed from iron ore; the pig-iron is melted and transferred to the furnace, which is fettled with iron ore; it is then treated with iron ore, which forms a slag which oxidizes the phosphorus and gives a slag containing phosphate. The temperature is kept as low as convenient. I spoke just now of manganese. They regard 1 per cent. of manganese as being absolutely essential. The reason of that is that the manganese protects the carbon. In working this process it is essential that the bath of pig-iron should not be allowed to "come to nature," that it should be kept fluid. The minute it begins to become wrought iron it becomes pasty; then the difficulties of removing it from the furnace become very great. When there is 1 per cent. of manganese the carbon is retained by the pig long enough to give sufficient time for the iron oxide to react upon the phosphorus and take it up.

Mr. MORGAN. So that phosphorus after all has a greater affinity for iron oxide than metallic iron?

Mr. DEWEY. Yes, sir; at that temperature. As far as that goes it has been known for a long time that it was a question of temperature; in fact in the puddle furnace there are times when the bath iron contains far less phosphorus than the finished iron. In other words, the phosphorus goes from the bath into the slag, and towards the end it goes back into the iron again owing to the increase of temperature necessary during the balling process.

Mr. MORGAN. Then in making steel with any ordinary or average ores I suppose you conclude that the results are dependent very largely upon manipulation?

Mr. DEWEY. Entirely so.

Mr. MORGAN. But when you have ores that are low in phosphorus and sulphur, even an unskilled steel-maker would be apt to produce a good article?

Mr. DEWEY. Yes, sir; the only thing in regard to the other ores is that it costs a little. The washing, of course, costs something. First-class steel ore when converted into pig will cost so much, ordinary ores will cost so much, and it will cost so much to wash ordinary pig. Now, will those two sums be greater than what first-class pig will cost, is the question to be considered from the commercial standpoint.

Mr. MORGAN. But not from the standpoint of your capability of making steel from the average ores?

Mr. DEWEY. Not at all. It seems to me that the process of washing pig in the bath of iron ore is one capable of very large and economical development, and one that is the most applicable to the subject you have in hand.

Mr. MORGAN. Where ores abound and are very cheap the expense of washing pig would be comparatively small?

Mr. DEWEY. Yes, sir.

Mr. MORGAN. So that what we call the Krupp process of washing is available and economical in countries where ores abound and where the haul is short?

Mr. DEWEY. Yes, sir.

Mr. MORGAN. Have you tried any other process of dephosphorizing metals or ores?

Mr. DEWEY. That is the only one I have ever tried. I am familiar with the Bessemer basic process from reading.

Mr. MORGAN. What advantage do you think the basic process has over the Krupp process in point of economy?

Mr. DEWEY. You cannot really compare the two, because the product from the Krupp process is not suitable for Bessemerizing, and is only suitable for open-hearth work, because in order to be successful the silicon must be kept low.

Mr. MORGAN. And in the Bessemer process you need the silicon to keep up the heat?

Mr. DEWEY. Yes, sir; that is the ordinary acid process. In the basic converter the silicon is replaced by phosphorus, the silicon is kept as low as convenient to run the phosphorus up; the reason being that the slag that is formed in the converter will not take up much phosphorus after the percentage of silica gets above 20. If the silica is kept down then larger amounts of phosphorus will go into the slag. In order to keep the silica low it is necessary to line the converter with basic material—magnesian lime—and, if necessary, to add lime during the blow. Sometimes iron ore is added during the blow. The slag is essentially a phosphate and not a silicate. A large amount of phosphorus is economically removed in that way. The only direct experience I have had with this process is the fact that a large amount of blooms made in England by this process were rolled into rails at Chattanooga.

Mr. MORGAN. Please describe the difference between the basic and acid processes as used by the Bessemer converter.

Mr. DEWEY. The acid process derives its name from the fact that the converter is lined with what is called ganister—a form of quartz which is an acid. The slag which is produced is an acid, silicate of iron and

manganese, the iron and manganese coming from the oxidization of the metal. But in the basic converter the lining of the vessel is magnesian lime and the slag is essentially a phosphate of lime and magnesia containing iron and manganese also; a small amount of silicate coming from the oxidization of the silicon in the metal is also formed.

Mr. MORGAN. In either case the converter is to be prepared before every charge is carried?

Mr. DEWEY. Yes, sir.

Mr. MORGAN. And in using the Krupp process in the open-hearth furnace you would only be required to make the preparation by lining?

Mr. DEWEY. You would have to properly prepare the bottom of your furnace.

Mr. MORGAN. I know, in that case.

Mr. DEWEY. You do not mean in the repairs of the vessel. They are not as great, as a general thing, as they are in the open hearth. The greatest wear in a vessel converter is on the bottom. That is why the bottoms are always removed for repairs.

LETTER FROM THE ALBANY AND RENSSELAER IRON AND STEEL COMPANY.

TROY, N. Y., *August* 7, 1884.

GENTLEMEN: Owing to your circular of July 16, 1884, not reaching us until a day or two ago, we have been unable to address you at any earlier date. It may now be too late to meet your wishes, but we think it due to ourselves and to the interests of this section of the country to address you.

While this company has not a plant for the manufacture of either steel guns or armor—and in fact, as far as our knowledge goes, no such complete plant exists in this country—at the same time we have a capacity for making 2,500 tons of Bessemer steel per week. The putting down of a suitable plant for the manipulation of this into other forms than those embraced by our present rolling-mills would depend entirely upon the encouragement given for such an investment.

As you know, our Bessemer plant was the first one erected in this country, and from its start has been a school for the development of the pneumatic process. We think we do not go too far in claiming that we are recognized as the leaders in the making of special steels in this country. We feel that, at our works, the state of the art is at least as high as at any Bessemer steel works in the world.

In this connection we would call your attention to the fact that, abroad, Bessemer steels are used for many purposes unknown to many Americans, and among them, guns and ship-plates. Bessemer steel can be made more uniform than is possible by the open hearth—or Siemens-Martin—process.

Our situation upon tide-water, and within so short a distance of the commercial center of the United States, would seem to indicate that no better site could be selected for Government work.

At the same time the Hudson River is so easily defensible that, in case of foreign war, the works would be comparatively safe.

As is well known, the iron ores of the Lake Champlain region are among the purest known in America; and, with so many competing lines of transportation, can be cheaply brought to meet the fuel from Pennsylvania, as well as other ores from the South, and even from foreign countries. The upper Hudson presents geographical features second to none for the establishment of either ship-yards or ordnance foundries. And with a United States Army depot located at Troy, combined with its many industrial advantages, it would seem to be a particularly suitable point for the execution of Government work.

Any facilities which may be in our power to extend to your committee in their investigations will be freely rendered, and we should be happy to receive a visit from you, when we could more fully impress you with the merits of our locality.

I remain, yours truly,

ROBERT W. HUNT,
Superintendent.

To the Select Committee, &c.

BETHLEHEM IRON COMPANY.

STATEMENT OF MR. JOHN FRITZ.

BETHLEHEM, PA., *February* 12, 1885.

The CHAIRMAN. Please state your name and present position.

Mr. FRITZ. John Fritz; superintendent of the Bethlehem Iron Company of Bethlehem, Pa.

The CHAIRMAN. Of what scientific association are you a member, and what statistics have you prepared on the subject this committee is investigating?

Mr. FRITZ. American Society of Mechanical Engineers and Institute of Mining Engineers.

The CHAIRMAN. Please give your age, and your practical experience in connection with said subject.

Mr. FRITZ. Sixty-two years. Have been active in the practical manufacture of iron and steel for the past forty years. Have also in the last few years visited and examined all of the principal steel works abroad, including those at Essen.

The CHAIRMAN. Please give a general description of the iron and steel furnaces, foundries, and mills worked by the Bethlehem Iron Company, the number of operatives necessary to carry on the work, and the amount of capital invested.

Mr. FRITZ. The entire plant has been erected from designs made here, and the machinery, engines, roofs, &c., have been built, with few exceptions, in the machine shops and foundry of the works. The buildings are of hard gray sandstone from adjacent quarries, and the roofs, covering several acres, are of slate from the vicinity. These works, from an early period of their existence, have commanded the attention and interest of iron and steel men both at home and abroad, and present an unbroken record of advance. Here may be found the birthplace of many devices and many methods now incorporated in the general manufacture of iron and steel. It was of these works that the late Alexander L. Holly said: "I never come but that I go away with something good."

Blast furnaces.—The company are now working eight anthracite blast furnaces. The principal dimensions of these furnaces are:

Furnace.	Height.	Bosh.	Hearth.
			Ft. In. Ft. In.
No. 1	62	16	8 6 by 7 6
No. 2	70	17	
No. 3	50	13	7 0 by 6 0
No. 4	70	17.2	8 6 by 7 4
No. 5	70	18.6	8 6 by 8 10
No. 6	70	17	10 8 by 8 8
No. 7	70	19	8 6 by 10 0
No. 8	64	16	8 6 by 8 0

The eight furnaces now working are run exclusively on Bessemer pig. The weekly yield averages 3,000 tons. The weekly yield per furnace is as follows:

Furnace.	Products.	Furnace.	Products.
	Tons.		Tons.
No. 1	280	No. 5	500
No. 2	500	No. 6	500
No. 3	250	No. 7	350
No. 4	400	No. 8	300

Furnaces Nos. 2 and 5 have made as much as 600 tons each week for weeks together. A choice variety of ores from the most celebrated mines at home and abroad enables these works to manufacture Bessemer metal of very superior quality.

The Bethlehem Iron Company's furnaces are also widely known for their excellent foundry iron. Those who are familiar with the difficulties of working anthracite furnaces will appreciate the manner in which the Bethlehem furnaces are run, when it is stated that the No. 1 furnace was run for seven years without blowing out, and made 70,000 tons of pig iron on one lining.

The horizontal compound blowing engines embrace some novelties of arrangement which the results fully justify. These engines work at high speed and under high pressure with a degree of smoothness and noiselessness which are rarely observed in a blowing engine. A strong feature in these engines, and one now generally recognized by the blast-furnace engineers, is the capacity of blowing as high a pressure as 20 pounds of air; this pressure sometimes being necessary to save the furnace and obviate expensive delays.

Furnaces Nos. 1, 2, 4, 5, and 6 are situated in a straight line, running parallel with the Lehigh Valley Railroad, and arranged to deliver the melted iron direct to steel works. The stock-house, placed as near the furnaces as convenience will permit, is a continuous building, running parallel with the line of furnaces and to their full extent.

The cast-house of each furnace is at a right angle, and forms a wing to the stock-house. The stock-house is 61 feet wide, and a double track runs the length of the building on trestles 12 feet above the floor level. The stock-house floor is divided off into spaces on each side, and a central aisle renders all parts accessible. The spaces intervening between the cast-houses are used for cinder yards on one side, and on the other are located the boilers and hot-blast stoves. Nos. 2 and 6 are supplied with the Siemens, Cowper, Cochrane fire-brick stove, and have been giving good results and entire satisfaction. The engine-house, separated from the furnaces by the stock-house, is a massive stone building, 60 × 327 feet, erected with the special view of protecting the blowing machinery from the dust and dirt of the furnaces. It contains six horizontal blowing engines. Four are compound; steam cylinders, high pressure 30 inches diameter, low pressure 54 inches diameter, 80-inch stroke; blowing cylinder 80 × 80 inches. The other two engines are single, condensing; steam cylinder 54 × 80 inches, blowing cylinder 80 × 80 inches.

Furnace No. 3 stands several hundred yards below the furnaces just described, and on the other side of the Lehigh Valley Railroad. Furnace No. 7 is located at Bingen, a station on the North Pennsylvania Railroad, about 6 miles from Bethlehem. This furnace was bought from the North Pennsylvania Iron Company in March, 1879, and has

been run continuously since. Furnace No. 8 is on the line of the Lehigh Valley Railroad, about 2 miles below the works, and is held under a lease from the Northampton Iron Company, as before stated.

Shops.—The machine shop, a stone structure (253 by 64), and the foundry (107 by 64), also of stone, and forming an L with the machine shop, were completed in 1868. They lie just above the line of furnaces described, and on the same side of the railroad. An addition has been made in brick to the foundry for core-making. A forge shop of brick, with iron and slate roof, joins the machine shop with the iron mill. The equipment of these shops is complete for the nature of the work handled. The foundry is supplied with two cupolas and three powerful cranes. Castings of 20 and 25 tons are often turned out. In the machine shop are many heavy tools; two large iron planers of William Sellers & Co., the larger being the 120-inch planer exhibited at the Centennial by the above firm; two large universal drills of Bement & Sons, the larger having a span of 14 feet; a large boring mill built in the shop; three heavy roll-lathes complete the list of heavy machinery, in addition to which are many lighter tools. The forge-shop is supplied with 10 forges and a double-acting steam hammer.

Iron mill.—This mill is furnished with fourteen double puddling furnaces and nine heating furnaces. These furnaces are set with boilers supplying steam to the mill. There is a 21-inch puddle train, rail train, and merchant train. The puddle train and rail train were formerly supplied with duplicate engines, 40 inches diameter by 32-inch stroke.

During the age of the iron rail this mill, on a 21-inch rail train, turned out per year 21,000 tons of rails on a single turn, as tops and bottoms were rolled on the night turn.

With the advent of the steel rail this train was altered to 22 inches and a 44 by 44-inch Porter-Allen engine substituted. The merchant train is run on both iron and steel. This mill now turns out about 1,500 tons of iron and from 3,000 to 4,000 tons of steel per month.

Steel works.—The steel works were commenced in 1870, and were completed in 1873. The first heat was blown October 4, and the first rail rolled October 18, of that year. In 1874 the spiegeleisen furnace was built. The company is now turning out spiegel of high quality.

Steel mill.—This mill is a large and massive stone structure, having numerous and uniform arched openings in its sides, and an iron and slate roof with a continuous lantern. The total length of the nave is 931 feet, and its width is 111 feet. The transepts are also 111 feet wide, and their total length, including the crossing of the nave, is 386 feet. The clear height is 29 feet. This building runs longitudinally east and west, parallel with the Lehigh Valley Railroad, and lies on the opposite side of the track from the rest of the works. In the eastern or upper portion of the mill is located the converting department, consisting of four 8-ton vessels. These vessels are arranged in a straight line across the mill, an iron platform supported on cast-iron columns surrounding them. Back of the vessels stand the iron and spiegel cupolas; they are supplied with double platforms, one above the other, commonly called the charging and tapping floors. These floors communicate with the vessel platform and with each other by means of iron stairs. Three vessels are worked alternately, while one is off for repairs; the iron cupolas are run four on and four off; the spiegel cupolas are run two on and two off. This method of working facilitates repairs and prevents the necessity of any excessive repairing or protracted delays. The vessels are wrought iron shells, 8 feet in diameter; the body is completely lined with natural stones of mica schist, roughly hewn to shape, and the nose is lined with fire-brick. A vast number of experi-

ments were tried before a natural stone could be found that would not either flake off under the heat of glazing or become rapidly denuded; the excellence of this stone depends on its mechanical structure, which of course is a thing hardly capable of description. Excepting some not expensive repairs to the nose, one of these linings is good for 30,000 tons of ingots. In the old plant 54,000 tons were made on the linings of the two vessels without the removal of any stones excepting in the nose and a few at the bottom joint. The vessel bottoms have 17 fire-brick tuyeres, with 12 holes, three-eighth inch each. Between the tuyeres are set on end bricks like the blast-furnace lining brick, as near together as they will stand. The small spaces left between the bricks and tuyeres are rammed with ordinary gannister bottom stuff, and so small is the total quantity of water in the bottom that it needs oven-drying only four hours; the bottoms stand 12 to 14 heats quite uniformly.

The spiegel cupola has a maximum internal diameter of 30 inches; diameter at tuyeres, 20 inches; there are four tuyeres 4 inches in diameter. This cupola is run with coke exclusively, and otherwise like the large cupolas. The output of the converting department averages 4,000 tons of ingots per week of eleven shifts; the plant has been worked at a higher rate of production. The heats of ingots run from 7 to 8 tons, according to the weight of rail. Fourteen-inch ingots are bloomed down to 7 inches square, and cut into single-rail blooms for the rail mill. The stock, ladles, molten metal, ingots, &c., are moved by a system of narrow-gauge tracks. This system, by means of frequent turn-tables, hydraulic lifts, and three-way switches, offers a complete and convenient conveyance. The casting-pits and handling floor are under complete command, with a systematic arrangement of hydraulic cranes.

The blowing machinery is located in the upper transept, next the railroad. There are two Bessemer blowing engines of the following dimensions: The smaller has two steam cylinders, 36 by 60 inches, coupled direct with two blowing tubs, 48 by 60 inches. The blowing tubs are placed back of the steam cylinders and on the same bed-plate; the steam cylinders are coupled on their forward end through cross-heads and connecting rods to a fly-wheel shaft, whose cranks stand at right angles. The larger engine has two steam cylinders, 56 by 66 inches, and two blowing tubs, 60 by 66 inches, arranged like the smaller. The smaller was the original engine, but proving inadequate to the demands of the increased plant, it has been substituted by one more powerful, and is now used as a reserve or emergency engine. The large blowing engine, running with 50 pounds of steam, is capable of maintaining a blast pressure of 40 pounds of air. The cupola blast is obtained from four No. 7½ Baker blowers, coupled direct to the shaft of a compound engine, running 90 revolutions.

The blast pressure at the blowers is 1¼ pounds, and 12 ounces at the tuyeres. Another compound engine, directly coupled with four blowing tubs, is kept in reserve for the cupolas.

A Worthington duplex and two Worthington compound-duplex pumps are also located in this transept, and supply a water pressure of 300 pounds to the square inch, for the operation of cranes, hoists, &c.

In the opposite transept are two Pernot furnaces, with their accompaniments. Just outside this transept is the ladle-house, supplied with a number of short tracks and turn-tables. The freshly lined ladles are placed on cars and run into position on these tracks; when in position a cap is lowered upon the ladle, and a stream of gas and air, in regulated proportions, admitted through the center of the cap, forms a combustion chamber of the ladle, causing more rapid drying and producing

hotter ladles than could be obtained by the old method of building fires in them. The number of ladles required is considerably reduced by this method.

The vessel-bottom repair-shop is located in the upper end of the mill, and is furnished with hydraulic cranes for handling and ovens for drying.

At this end of the mill a brick foundry has been erected on the south side and adjoins the mill. This foundry is used for the manufacture of ingot-molds, the consumption being 6 to 8 per day. The foundry equipment consists of a cupola and two power cranes.

In the main portion of the mill, just below the pits and handling floor, are 6 Siemens reheating furnaces. Three furnaces are placed on each side, with hydraulic cranes for charging and drawing the ingots. Centrally, between these furnaces and under command of the hydraulic cranes, run two narrow-gauge tracks, one running to the casting pits, the other to the blooming train. There are two blooming mills, two engines, and three sets of rolls. The smaller engine is 36 by 60 inches, coupled direct to two sets of three high 32-inch rolls. Both sets are supplied with tables, operated by power and controlled by two levers at one point. The large mill is also three high; the rolls are 48 inches diameter and 10 feet long: the engine is 65 inches by 8 feet, with 90-ton fly-wheel; this mill is similar to the smaller, but handles a larger ingot. From the blooming mill the ingot passes to a steam hammer outside, cut into rail blooms, brought back and charged into the rail-mill heating furnaces.

These furnaces (4 in number) are similar in construction to the blooming mill furnaces, varying only in size, and are located immediately below the blooming mill. The rail mill consists of three sets of rolls; the engine is an upright compound, 36-inch high pressure and 56-inch low pressure cylinders, 50-inch stroke; the rolls are 24 inches, three high. The rail passes from the rolls to the hot-saws, and thence to the hot-beds, straighteners, drill-presses, and punches, that occupy the lower end of the mill. From this point the rail passes to the car for shipment.

There is now in course of erection, and nearly completed, a new mill designed to roll heavy sections and long lengths. This train will be driven by three high speed compound engines on one shaft, connected with the middle roll and driving direct. The aggregate power of these engines will be 8,000 horses. In connection with this train will be the necessary tables, which will be of novel design, worked automatically by water or air for handling the material.

These works from small beginnings have grown to proportions producing an output second to none in the country in quality or quantity. The average force is 3,000 men and boys. The many difficulties of construction arising, with a constant demand for increased capacity and facilities, have been met with unfailing skill and foresight, fully attested by the successful and convenient working of so large a plant.

The annual product of the works is as follows:

	Tons.
Pig Iron	120,000
Ingots	200,000
Rails	150,000
Billets	30,000

The CHAIRMAN. Have you at any time been requested by any Government to supply steel shafts, engines, boilers, ship plates, guns, armor, or steel for the same?

Mr. FRITZ. Have not.

The CHAIRMAN. What are the dimensions of the largest steel shafts, forgings, castings, armor, gun parts, boiler or ship plates you have manufactured?

Mr. FRITZ. Have made steel shafts and castings for our own use. Have made cast shafts of 14 inches diameter, and forged a 12-inch shaft under a seven-ton hammer; have made a large variety of steel castings running as high as 8,000 pounds.

The CHAIRMAN. By what process were they manufactured?

Mr. FRITZ. By the Terre-Noiré process, in connection with Bessemer steel.

The CHAIRMAN. Are there any forges in the United States capable of properly forging steel shafts for ships of more than 1,500 tons, and the parts of modern ordnance heavier than six inches caliber?

Mr. FRITZ. None to do it properly.

The CHAIRMAN. Are there any rolls in the United States of sufficient capacity to roll armor-plate of more than 2 inches in thickness?

Mr. FRITZ. There is no mill capable of rolling *heavy* armor-plate.

The CHAIRMAN. Where is the boundary between iron and steel?

Mr. FRITZ. A vexed question, on which doctors disagree.

The CHAIRMAN. What is the action of metal called "flowing"?

Mr. FRITZ. A molecular displacement due to compression or other strains.

The CHAIRMAN. Could all the parts of a 100-ton steam hammer be manufactured in the United States.

Mr. FRITZ. All parts of a 100-ton hammer could be made in the United States, but would prefer having the piston-rod forged under a hammer heavier than any in this country, or in an hydraulic forging press, of which there are none in this country adapted to the work.

The CHAIRMAN. By what method can the Government best be supplied with guns, armor, and war vessels?

Mr. FRITZ. Think favorably of the method suggested by the United States Gun Foundry Board.

The CHAIRMAN. What is your opinion of the comparative cost of supply—wholly in Government works, partly in such works and partly by contract with private builders, or wholly in private works? In case of divided labors, how should the division be made?

Mr. FRITZ. This question would be difficult to answer intelligently without considerable thought and consideration; yet it would seem that the plan recommended by the Gun Foundry Board would offer the best solution of the problem.

The CHAIRMAN. Which do you consider the best location for such a method of production?

Mr. FRITZ. I consider Eastern Pennsylvania one of the best locations for the manufacture of the rough-finished material.

The CHAIRMAN. Is there material in this country out of which the best gun steel can be made?

Mr. FRITZ. There has not been sufficient demand at home for such a product to determine if the best gun-steel can be made of American material. It is believed, however, that material of suitable quality exists in the United States, though perhaps not near enough to the localities suitable for the manufacture of guns to give as good economic results as can be had by the use of some foreign material.

The CHAIRMAN. Is there any reason why the steel manufacturers of the United States should not be restricted to the use of home material?

Mr. FRITZ. There are several reasons for not restricting the manufacture to home ores; an important reason being the purer quality of

many of the foreign ores which insures a higher grade and better quality of steel.

The CHAIRMAN. Why do steel manufacturers import foreign material?

Mr. FRITZ. Because they can feel more certain of obtaining a high quality of product within the necessary limits of cost.

The CHAIRMAN. Can any works in the United States (with present plant) produce any grade of steel that would probably be called for by Government specifications for guns and armor equal, metallurgically, to foreign?

Mr. FRITZ. Several works in the United States are capable of supplying steel equal metallurgically to the foreign steel.

The CHAIRMAN. Under existing conditions what will be the additional cost of such steel as compared with the foreign of the same quality, laid down in the United States, duty free?

Mr. FRITZ. About the difference in the price of labor.

The CHAIRMAN. By what process would you make, and to what treatment would you subject, the steel for modern heavy guns, armor plate, and plates for boilers and ships?

Mr. FRITZ. Would make the steel by such process and subject it to such tests as the United States Government might suggest or require.

The CHAIRMAN. If the Government specified the minimum physical characteristics, without indicating the process of manufacture, by what process would you manufacture, and to what treatment would you subject, the steel in order to produce the most suitable material for modern heavy guns, armor-plate, and plates for boilers and ships?

Mr. FRITZ. The experience of the most celebrated manufacturers of heavy ordnance having led to the adoption of the open-hearth process, may be accepted as proof of its adaptation for the manufacture of heavy guns. The treatment of the metal whereby it is brought to shape can no doubt be effected equally well either by the steam hammer of great weight or the hydraulic forging press. The choice of method would thereby be governed by the respective cost. If the Government should adopt a solid steel armor plate, the same plant used in making the guns could to a great extent be used in the fabrication of this armor. Boiler plate and shapes for ship-building purposes must necessarily be made on rolls. While the open-hearth process is generally preferred, and certainly yields a good product, I am strongly of the opinion that equally good results can be obtained from the Bessemer.

The CHAIRMAN. How is steel tempered; and why is oil generally used instead of other fluids?

Mr. FRITZ. Steel is tempered by cooling—suddenly for hard tempering, but slowly for toughness. Oil is used because experience has proved it less liable to produce cracks than other fluids.

The CHAIRMAN. Why is not petroleum used?

Mr. FRITZ. Because the formation of explosive gases renders it dangerous.

The CHAIRMAN. In what way is the quality of steel improved by working and treatment? Is the density increased?

Mr. FRITZ. Its density is increased, thereby improving its strength and ductility.

The CHAIRMAN. In what part of the United States are the most suitable ores to be found for the manufacture of gun and ship steel?

Mr. FRITZ. Not knowing the Government requirements for gun and armor plates, I cannot answer this question intelligently.

The CHAIRMAN. Have we the material, plants, and experience required to produce in quality, dimensions, and quantity, steel suitable

for the construction of modern armored vessels, and for the fabrication of modern heavy ordnance?

Mr. FRITZ. There is in this country no plant capable of producing steel in such dimensions or quantity suitable for the construction of modern armored vessels, and the fabrication of modern heavy ordnance.

The CHAIRMAN. Have you ever compressed steel ingots in a liquid state, or seen the operation of such compression, or hydraulic forging?

Mr. FRITZ. Have had practically no experience in compressing steel ingots in liquid state, or of hydraulic forging.

The CHAIRMAN. What do you know of liquid compression?

Mr. FRITZ. Practically, nothing.

The CHAIRMAN. Have you ever manufactured hydraulic casting or forging presses?

Mr. FRITZ. No.

The CHAIRMAN. What do you consider the comparative advantages and disadvantages of the two systems of forging (hammer and hydraulic press), and what are your reasons for the same?

Mr. FRITZ. I consider the advantages in favor of the hydraulic forging press, because the process is more of a kneading one, its effect going to the center, consequently increasing uniformly the density throughout the mass.

The CHAIRMAN. Have you any tools and implements for the manufacture of guns similar to those mentioned in the Gun Foundry Board's report, pages 40 to 44; can you manufacture such tools, equal in power and feed, at the cost estimated therein; and how much time would you require to furnish them?

Mr. FRITZ. We have several tools and implements coming under this head, but keep them in constant use on our own work. We could make such tools, but might prefer to get them elsewhere, reserving our power for things that could not be made anywhere else.

The CHAIRMAN. Are you enlarging your plant?

Mr. FRITZ. Enlarging in the direction of shapes for ship-building and other purposes.

The CHAIRMAN. In the manufacture of steel, to what chemical and mechanical tests do you subject it?

Mr. FRITZ. Complete chemical analyses, and tested for its physical and mechanical properties, *i. e.*, bending, tensile strength, elongation, elastic limit, torsion, effects of temperature, and microscopic investigation.

The CHAIRMAN. What testing machine do you employ?

Mr. FRITZ. Rhiele's tension, transverse and compression testing machine, and Thurston's torsion machine.

The CHAIRMAN. By whom are these tests made?

Mr. FRITZ. Maunsel White, graduate of Stevens Institute, in charge of our physical laboratory.

The CHAIRMAN. What ores do you use, and where do you get them?

Mr. FRITZ. Carbonate, magnetic and red hematite. About half American and half foreign.

The CHAIRMAN. What experience have you had in the use of steam hammers and hydraulic casting and forging presses?

Mr. FRITZ. None with hydraulic presses, but have been using steam hammers of from 5 cwt. to 7 tons for the past 35 years.

The CHAIRMAN. What testing machine do you consider best adapted for the work required in the production of suitable steel for war vessels and heavy ordnance, and your reasons?

Mr. FRITZ. There are several machines now being built and in use which can be relied on for trustworthy results.

The CHAIRMAN. In the production of such steel (with equal care of manufacture) can as good results be obtained by washing, &c., medium and poor ores, as with the best selected material?

Mr. FRITZ. In making a high grade of steel the purest ore is much to be preferred. No subsequent treatment can make up for original defect in quality of ores.

The CHAIRMAN. Do you consider the proximity of natural gas an advantage to steel manufacturers?

Mr. FRITZ. There are some advantages, but other localities possess advantages more than counterbalancing those of the natural gas.

The CHAIRMAN. What is your opinion as to its comparative reliability, sufficiency, safety, cost, and purity with other fuels?

Mr. FRITZ. Consider the gas manufactured from solid fuel as of more reliability and safety, but costing somewhat more than the natural gas.

The CHAIRMAN. Is it found in large supply in the vicinity of your works?

Mr FRITZ. No natural gas found in our vicinity.

The CHAIRMAN. Please give a record of tests of your steel.

Mr. FRITZ. Having made as yet no steel for gun or ship purposes, can give no tests of such material.

LETTER FROM THE BRIER HILL IRON AND COAL COMPANY.

YOUNGSTOWN, OHIO, *July* 30, 1884.

GENTLEMEN: I have received your circular, dated at Washington, July 16, 1884, which I have carefully read. We are manufacturing at Brier Hill, by the direct process, 45 or 50 tons per day of "washed metal," suitable for open-hearth steel. We believe this to be the best steel material ever produced in the United States. It is entirely free from silicon, contains but a trace of sulphur, and about 3 per cent. of combined carbon. It can be used in an open-hearth plant alone.

We believe it is just the material needed for manufacturing the proposed steel guns. It would give us pleasure if your committee would see proper to pay us a visit on this subject. I might add, also, that there are a great many worse locations in the United States than Youngstown for a gun foundry. We have six railroads here, and are connected with nearly all the leading roads in the country.

Very truly, yours,

J. G. BUTLER, JR.,
General Manager.

To the Select Committee, &c.

Inclosed in the above letter was the following:

AMERICAN "SCOTCH PIG."

It may not be generally known that the Brier Hill Iron and Coal Company, owning and operating blast furnaces at Youngstown, Ohio, are turning out an iron which they call "Brier Hill Scotch," and which is said to be fully equal to the imported article. The Brier Hill Company, while making a very good Bessemer iron, have for some time been paying special attention to foundry irons. Some three or four months ago they conceived the idea of making a grade of foundry iron equal to imported Scotch. The latter iron is usually purchased on account of its well-known qualities of great fluidity, slight shrinkage in casting, and scrap-absorbing power; and it is asserted that the Brier Hill Scotch is identical, in physical properties, with the imported Scotch, and that it is very difficult to distinguish the difference between them. The iron of the Brier Hill Company has been tried in numerous instances by parties who had been using nothing but the imported Scotch, and we are informed that, with scarcely an exception, it has filled the bill and done the work of the latter. The Brier Hill Company are now running one of their four blast furnaces exclusively on this iron, and are shipping it to fifteen different States in the Union. The iron is graded as Nos. 1 and 2, the No. 1 being extra open grade, and the No. 2 varying but little in appearance from No. 1 imported Scotch. They use as a basis for making the metal the celebrated Mineral Ridge black band ore, which is identical in analysis with the best quality of Scotch black band. The company are also making, in addition to their Bessemer pig and their Scotch foundry, two other grades of foundry iron—an extra strength iron called "Tod foundry," made from Lake Superior ores, very tough, soft and fluid, and suitable for difficult machine work—and a medium strength iron called "Iron River foundry," suitable for small castings and general use. Special attention is given to grading these foundry irons, and purchasers can rely on qualities and strength.

The Brier Hill Company are now able to supply to foundries their entire mixture, thus obviating any necessity to buy from several different makers. The four furnaces of the company have an aggregate annual capacity of 100,000 tons, and their product, for the past three years has averaged 75,000 tons per annum.—*The Iron Age, March* 1.

LETTER FROM THE CAMBRIA IRON COMPANY.

PHILADELPHIA, *July* 29, 1884.

GENTLEMEN: We yesterday received your circular of the 10th instant, same having been forwarded from our works, and we would respectfully reply thereto that we have been considering for a long time the subject of which it treats and have been endeavoring to post ourselves that we may give an intelligent answer to the various inquiries that the Government may desire to make of us. On February 7 we addressed a long communication to Commodore Edward Simpson, president of the Gun Foundry Board, which you will find printed in full on page 61 of the report of that Board, which latter you no doubt have before you. We have nothing now to add to what we there set forth; but to enable us to act more intelligently in the matter, we have sent our chief engineer to visit the various European works that are engaged in furnishing the class of material that the Government desires, and within a short time—when we obtain his report on his various visits—we will be enabled to make a fuller statement. In the mean time we would be exceedingly glad to have you and your committee, or any of you, visit our works, and when there every facility will be afforded you to make a complete examination of the same.

Awaiting your advices as to this, and hoping to communicate with you further in regard to the matter, we remain,

Very truly, yours,

E. Y. TOWNSEND,
President Cambria Iron Company.

To the Select Committee, &c.

CAMBRIA IRON COMPANY.

STATEMENT OF MR. JOSEPH MORGAN, JR.

JOHNSTOWN, PA., *November* 25, 1884.

Mr. MORGAN. What is your profession, and how long have you been engaged as chief engineer of the Cambria Iron and Steel Works? How long were you in the United States Navy, and in what capacity?

Mr. J. MORGAN, Jr. My profession is mechanical engineer. I have been chief engineer and superintendent of the mechanical department of the Cambria Iron Works for four years past. I served from October, 1861, to January, 1866, as third and second assistant engineers in the United States Navy. Since my resignation I have been three years at the Phœnix Iron Works, Phœnixville, Pa.; ten years at the Edgemoor Iron Works, Wilmington, Del., and six years at the Cambria Iron Works.

The CHAIRMAN. Of what scientific association are you a member?

Mr. J. MORGAN, Jr. Am a member of American Institute of Mining Engineers, American Society of Mechanical Engineers, and of United States Naval Institute.

Mr. MORGAN. Please give a general description of the classes of work in iron and steel production and manufacture that is being carried on at Johnstown by the Cambria Iron and Steel Works, the number of operatives necessary to carry on the works, and the amount of capital invested by the company; also the number and description of the iron and steel furnaces, foundries, and mills worked by the company, and the number and location of the iron-ore beds and coal-mines worked by the Cambria Company.

Mr. J. MORGAN, Jr. The company now own seven blast furnaces in Cambria County and four in Blair County, besides extensive properties in the Lake Superior region. The Pennsylvania properties are abundantly supplied with railway facilities, by which the cost of transportation is reduced to minimum limits. The company own twenty-three locomotives of from 6 to 37 tons weight, three hundred and sixty standard-gauge and about one thousand narrow-gauge cars. Nine thousand car-loads of material are handled each month. The mills cover 7 acres and the works 60 acres.

The rolling mill is 85 to 100 feet in width by 1,900 feet in length; the Bessemer mill, 105 by 265 feet; the merchant steel works, 105 by 162 feet; the open hearth steel works, 120 by 355 feet; and all the other works are of similarly large dimensions.

The rolling mill contains a 21-inch train, No. 1, of three stands of three high rolls, driven by a 40 by 48 inch horizontal engine. The average output of the mill is 3,000 tons of finished rails a week, the actual output reaching in the best record of one of the mills one hundred and ten steel rails in fifty-five minutes. The blooms are 7 inches square, and the furnaces have a capacity of ten blooms each.

No. 2 train is 21 inches, and has three stands of three high rolls, driven by a vertical engine, 40 by 32 inches, and is worked on double-length rails, angles, and other steel shapes. The capacity of the mill is 1,200 tons of small steel shapes per week.

No. 3 train is 21 inches, with three stands of three high rolls, the engine being a duplicate of No. 1 train. It is worked on wire-rod billets and the various other kinds of billets required for merchant steel; capacity, 800 tons per week.

No. 4 train is 21 inches, similar to the others; capacity, 600 tons per week. This mill has been used to roll rail blooms, 7 inches square, during the temporary stoppage of the 40-inch blooming train. Bulkley condensers are used on all the engines driving the trains.

The 16-inch mill of three stands of two high rolls is driven by a horizontal engine of 20 by 30 inches, and is used for making various kinds of merchant iron; capacity, 250 tons per week.

The 12-inch train has three stands of three high rolls, driven by a vertical engine 11 by 21 inches. It is used for splice bars, light angles, track-bolt iron and light rails 16 to 24 pounds; capacity, 125 tons per week. The stock is heated for the foregoing in thirty-five heating furnaces with overhead steam boilers. The mill has in addition to these boilers, a brick and iron building 45 feet by 180 feet, containing sixteen tubular boilers, 60-inch diameter, aggregating about 1,600 horse-power.

The puddle mill, which has forty-four double puddling furnaces, roll trains, engines, &c., is not now worked except for occasionally rolling iron scrap.

The wire-rod mill is engaged in rolling steel billets into No. 5 rod, and its average output is 400 tons a week. The billets are heated in a Siemens' furnace 25 feet long 10 feet wide, inside dimensions. The producers connected with the furnace are worked with steam jet blast. The engines are supplied with steam by six tubular boilers, 60-inch diameter and 18 feet long.

The department, wherein are made the track bolts for railroads and the machine bolts used throughout the works, is equipped with bolt-heading and nut-tapping machines of the most approved patterns. It produces 1,000 kegs of track-bolts, of 200 pounds each, each month, besides supplying about 30,000 pounds of machine bolts per month.

A ventilating fan of 8 feet diameter supplies fresh air to the rail-mill through main pipes 5 feet in diameter, located overhead, and having outlets near the heating furnaces, 2 feet in diameter. By this arrangement 100,000 cubic feet of fresh air per minute is distributed throughout the works.

The 40-inch blooming train for blooming 18½-inch ingots is driven by a reversing engine with two cylinders, 40-inch diameter, 48-inch stroke, and is geared to the train, three to one, with engine speed at ninety revolutions per minute. The train is two high. The tables on both sides of the train are operated by hydraulic cylinders, and the screws for controlling the height of the top roll are actuated by the same power. The ingots weigh 5,000 pounds each, and are rolled into 7-inch blooms, each ingot making six to eight rails. Siemens' heating furnaces, eight in number, are used, having an aggregate capacity of sixty-six ingots. They are supplied with power drawing and charging apparatus.

Twenty Siemens and four Wilson's producers are used, steam blast being gradually substituted for natural draft throughout. The new blooming train, now nearly completed, will be 48 inch, two high, driven by a pair of horizontal reversing engines, 44-inch cylinders, 60-inch stroke, at a speed of sixty revolutions per minute, geared two to one to the train. The rolls, which are of steel, cast in the open-hearth department, are 8 feet long between necks, 44-inch diameter, cored 20-inch diameter through the body, and weigh about 16 tons. The ad-

justable screws are actuated by a small two-cylinder reversing engine. The tables are 8 by 30 feet, and are driven by bevel gearing on the end of each roller, power being supplied by a horizontal engine placed at one end of the table. A pair of hydraulic cylinders push the finished bloom sidewise to the delivery rollers which carry it to the hot shears. The shears are driven by a 14-inch by 24-inch vertical engine. This train, when finished, will be as powerful and as capable of rolling as heavy armor plate as any mill in Europe. The foundations of the train and engines are constructed in a most substantial and durable manner, of cut stone, 12 feet deep, laid upon a concrete bed 3 feet deep. Both blooming trains are served by 25-ton cranes for changing rolls, pinions, &c., besides the 4-ton hydraulic cranes for handling ingots.

A Sellers 4-ton and Condie 5-ton steam-hammer are located conveniently near the trains.

Twelve soaking pits, of the Gjers type, are within 20 feet of the 40-inch train. They are 10 feet deep below ground and are served by a hydraulic crane of 24-foot jib.

Hydraulic pressure is maintained by a Worthington compound duplex pump, connected with accumulators, giving 350 pounds pressure per square inch. The product of the 40-inch train for the past year reached 200,000 tons of ingots bloomed.

Steam for the blooming mill and open-hearth plants is generated in twenty 48-inch and four 60-inch by 18 foot tubular boilers.

The Bessemer plant was started in 1871, and is of the American type. The converting room is of iron and brick throughout, and has ample height and ventilation. The cupolas are six in number, 7 feet 6 inches in diameter, and 25 feet high. Blast is supplied by four Baker rotary pressure blowers and one Sturtevant blower, each driven directly by a 16-inch by 24-inch independent engine, which furnishes to these and to four smaller cupolas for melting spiegeleisen, 33,000 cubic feet of blast per minute. The capacity of one cupola is 600 tons of melted iron at a continuous blast of seventy-two hours. The cupolas supply two converting vessels of 7½ tons capacity each, the product of the vessels being distributed by a hydraulic ladle crane. Blast is supplied at about 20 pounds pressure by three blowing engines of modern type, 54-inch air cylinders, 5½-foot stroke.

There are in the Bessemer works two Worthington compound pressure pumps, connected with the accumulators in the blooming and open-hearth departments, so that the pressure is likely to be constant and regular.

The Bessemer works are supplied with steam by a battery of nine 48-inch tubular boilers, and ten 60-inch plain horizontal tubular boilers.

The best average, although not the very highest work done in the Bessemer department, is eighty-two heats of 7½ tons each, for each twenty-four hours. The best weekly record reached 3,700 tons of ingots, and the best monthly record 16,000 tons. The best daily output was 725 tons of ingots.

All grades of steel are made in the converter from the softest wire and bridge stock to spring stock. They are all carefully analyzed at the company's chemical laboratory, heat by heat, and the physical properties determined by a tension test made on a bar three-fourths of an inch square, and measured on 8 inches length. From the knowledge thus obtained the use to which it is to be applied is determined.

The open-hearth plant consists of three Pernot revolving-hearth furnaces, fitted with all the recent improvements in roofs and ports, and also arranged in accordance with the principles which have made the

American Bessemer works so much more productive and economical than those which preceded them. There are two 16-foot pans of 15 tons capacity each, and one 14½-foot pan of 12 tons capacity. Each one is supplied with gas by four Siemens producers. A separate pit, with an independent hydraulic crane of 20 tons capacity, is located in front of each pan, and hydraulic cranes of smaller capacity for delivering the ingots to cars are conveniently located. A steam crane of 25 tons capacity is also in use for special purposes. A large part of the product of this plant is made into special castings for use in and about the mills, for custom work, such as engine shafts, gearing, light and heavy rolls, bridge castings, &c. Cupolas are prepared to run the smaller pan on the Krupp dephosphorization process. The product of the two 16-foot furnaces reached 25,000 tons a year.

The company owns and operates ten blast furnaces. Six of the largest and most modern type are located at Johnstown, and the others on the lines of the Pennsylvania Railroad, adjacent to large coal and iron ore deposits. The Johnstown furnaces are 80 feet high, 16 to 19 feet boshes. They have sixteen Whitwell stoves, 19 feet diameter, 64 feet high; also stoves of the Player type. Fourteen blowing engines, with 84-inch air cylinders, supply blast which is heated to 1,200° Fahrenheit, and averages 8 pounds pressure per square inch. Steam is generated in seven batteries of steel twin boilers 43 feet long, 4 feet diameter, and five batteries of twin boilers 70 feet long, all so arranged as to be worked independently of each other.

The product of these furnaces can either be poured directly into ladles resting on trucks and run to Bessemer works, or cast directly into pigs.

The shops of the company, for building their own machinery and making the necessary repairs, comprise the following:

Machine-shop	65 by 215 feet.
Machine-shop, two-story annex	40 by 85 feet.
Smith-shop (octagon)	70 feet.
Smith-shop, two wings	40 by 60 feet.
Foundry	75 by 165 feet.
Foundry	75 by 145 feet.
Roll-turning, boiler, and roof shops	110 by 315 feet.
Pattern shop, two stories	55 by 110 feet.
Car and carpenter shops, two stories	60 by 140 feet.
Testing department, two stories	50 by 100 feet.
Plumbing shop, two stories	50 by 100 feet.
Drawing rooms, three stories	55 by 65 feet.

The machine-shop has among its tools for heavier work a combined slotter and boring mill, with a shifting table of 16 feet traverse, a slotting stroke of 4 feet vertical, and can accommodate a piece of work 6 feet by 12 feet by 16 feet, and slot, bore, and plane at one operation. In addition to this it has a full complement of lathes, planers, cylinder-boring, and floor-boring machines, drill presses, &c. These are served by one 25-ton, two 20-ton, and one 10-ton cranes. The machines for lighter work are on the second floor, which is reached by a 3-ton elevator. The tool-room, a wing 50 by 50 feet, is supplied with lathes, presses, gear cutters, &c., for making the more important tools used in the shop.

The smith-shop has twenty forges and three furnaces and four steam hammers varying from 1,000 pounds to 3,500 pounds, served by seven cranes.

The foundry has three cupolas and one air furnace, and has upwards

of 20,000 square feet of molding floor. It is served by two 25-ton, three 15-ton, and one 10-ton steam cranes.

The roll-turning department occupies a brick and iron building jointly with the boiler and roof shops. Its ten lathes are set in line and are served by a portable crane running on a tramway in front of them. The largest lathe will swing a 48-inch by 14-foot blooming-mill roll weighing about 16 tons, and the smallest is used for wire-rod rolls 7 inches by 10 inches.

The boiler-shop is fitted with all necessary power tools, and makes all the boilers which the company use, besides constructing and maintaining the necessary structural work connected with the blast furnaces and steel works.

The roof-shop is prepared for structural work entirely, and employs a large force on bridges, roofs, and floors.

The shops all have ample steam power in their respective buildings independent of each other.

The pattern, car, and carpenter shops have their motive power in one engine. They are fitted with wood-working tools for their several specialties.

The testing-room is equipped with one horizontal Riehlé testing-machine of 150,000 pounds capacity; one upright Gill testing machine of 100,000 pounds capacity; and one upright hydraulic testing machine of the Emery pattern of 300,000 pounds capacity, with all the latest improvements in tension, compression, or bending; one Thurston's autographic torsion testing machine; one wire testing machine; an oil tester; supplied with power by a 15-horse-power engine; improved instruments for accurate measuring; balance for specific gravity determinations, &c.

There is also an annealing and tempering furnace with bending machine.

The company own in fee-simple 51,423 acres of mineral land, and have leased 1,000 acres of Connellsville coking land, on which are five hundred coke ovens.

The Johnstown coal-mines have a capacity of 300,000 tons of coal per year. The mining face is 3 miles broad and 6 miles square. The Bennington mines, on the summit of the Alleghenies, produce 110,000 tons of good coking coal. The Frankstown fossil ore mines yield 30,000 tons annually, 45 per cent. of which is metallic iron. The Springfield mines consist of four sections of an extensive hematite ore range, and have produced 45,000 tons of good Bessemer ore yearly. The last-named mines are within 50 miles' radius of Johnstown.

The company has also extensive possessions in Michigan, in the Menominee region, which produce 350,000 tons of Bessemer ores yearly.

The limestone quarries are located at Henrietta and Hollidaysburg, Pa. * * *

The Gautier Steel Company, Limited, was established at Johnstown in 1878. It was purchased by the Cambria Iron Company in 1881. and became one of its branches, assuming the title of "Gautier Steel Department." Its works consist of a large wire mill, a steel-rolling mill, and a barbed wire mill. Connected with the rolling-mill, and under the same roof, are the spring, rake, finger bar, cold-rolled shafting, harrow-tooth, plow, and finished plow shape departments. The total area covered with buildings is a little over 6 acres. The wire mill covers an area of 97,850 square feet, and the departments are as follows: Fine wire room, fence mill, wet wire room, galvanizing room, tinning room, and staple room. The mill is fully equipped with acid tanks, cleaning tubs, bakers, annealers, mufflers, drawing blocks, galvanizing and tin-

ning baths, wire pointers, and straightening, cutting, twisting, and staple machines. It produces all kinds of market wire, annealed, bright, spring, coppered, tinned, and galvanized, for every purpose. The annual capacity for fence wire alone is 30,000 tons.

The mill is supplied with steam by a battery of twelve 60-inch tubular boilers.

The barbed wire mill covers an area of 23,550 square feet, and power is furnished by an engine 22 by 48 inches, making sixty-five revolutions per minute. It has a capacity of 3,500 tons per annum.

The rolling-mill.—No. 1 is a 9-inch train, driven by a Porter-Allen engine 13 by 24 inches, making two hundred and thirty revolutions per minute. It is used for tires, knife backs, nail rods, rivet steel, and machinery rounds.

The rod mill rolls a billet, $1\frac{1}{8}$ inches square, into a No. 5 wire rod in eleven passes. The capacity of the mill is 50,000 pounds per turn. It is driven by a Porter-Allen engine 24 by 42 inches, with a 15-foot fly-wheel weighing 17 tons, and carries a 48-inch double belt traveling at the rate of $1\frac{1}{4}$ miles per minute.

No. 3 train is 12 inches, 3 high, driven by a vertical engine 26 by 24 inches. Its product is toe calks, springs, hoe, rake, fork, axle steel, &c.

No. 4 train is 12 inches, 3 high, driven by an 18 by 30 inch engine. It produces toe calks, light angles, hoop, harrow, hexagon, and hinge steel.

No. 5 train is 20 inches, 2 high, driven by an engine 30 by 48 inches. It is used for plow slabs and shovel steel, and has a capacity of 250 tons weekly.

The finger-bar train is 20 inches, 2 high, driven by an engine 14 by 20 inches.

Twelve furnaces supply stock to the various trains.

The spring shop has a complete outfit of furnaces and machinery for manufacturing railroad, car, elliptic, Concord, platform, truck, phaeton, and coach springs. Its annual capacity is 1,500 tons.

The rake shop is fully supplied with tempering and retort furnaces, and all the necessary appliances for the successful manufacture of horse-rake teeth and has a capacity of 100,000 sets, or 2,000,000 teeth per annum.

The finger-bar department has a complete outfit of planers, punches, cutting-off machines, testing and straightening apparatus, and a large tempering furnace. The annual capacity is 125,000 bars.

The plow shop is fully equipped with large and special shears, and has an annual capacity of 10,000 tons.

The plant of the finished plow department is complete in every particular, and is composed of special steam drops, steam hammers, heating furnaces, and a fully equipped polishing department. The annual capacity is 5,000 tons.

The mechanical department comprises the pattern shop, blacksmith shop, and machine shop.

The machine shop is two stories in height; the lower story is occupied by the large tools, and the upper, which is reached by an elevator, is used for repairing tools and a lighter class of work. It contains lathes, drill presses, shapers, planers, &c., and is driven by a 10 by 12 inch double engine, making one hundred and sixty revolutions per minute.

The blacksmith shop is furnished with two iron cranes serving three fires, eight forges, and one steam hammer.

In addition to the above facilities for turning out work, the depart-

ment has a storehouse 43 feet by 237 feet, having a capacity for over 3,000 tons of wire and merchant steel.

The summarized capacity of the Gautier steel department per annum, is as follows:

	Net tons.
Wire	45,000
Barbed wire	3,500
Rolling-mill	40,000
Plow shapes and slabs	10,000
Finished plow steel	5,000
Carriage and railway springs	1,500
Harrow teeth	500
Cold rolled steel	2,500
Horse-rake teeth:	
Sets	100,000
Teeth	2,000,000
Finger-bars	125,000
Total number of employés of the Cambria Iron Company	8,225

The CHAIRMAN. Are you enlarging your plant?

Mr. J. MORGAN, Jr. We are extending our plant by rebuilding blast furnaces on most modern types, adding a heavy roll train and other improvements.

Mr. MORGAN. What ores are used by the Cambria Company in producing the iron from which their steel is made? Are these good steel ores and do they yield good steel of the several descriptions now in common use? Is the steel made by the Cambria Company suitable for making guns of high power, and ship and armor plates?

Mr. J. MORGAN, Jr. The ores from the mines previously named are used. The Lake Superior ores are good Bessemer ores and come from four of our own mines at Vulcan, Cyclops, Norway, and Quinnesec. Springfield is also a fair Bessemer ore. The Vulcan and Cyclops ores, when selected, are unusually good, and pig of these ores, when dephosphorized, will make steel of phosphorus, as low as, or lower than, the best Swedish pig. Steel of this grade of purity is what is needed for guns and armor plates.

All grades of steel are made at our works from the above-named ores, and our reputation for quality of stock is good.

The CHAIRMAN. Have you at any time been requested by any Government to supply steel shafts, engines, boilers, ship-plates, guns or armor, or steel for same?

Mr. J. MORGAN, Jr. The Cambria Iron Company have been asked to supply gun forgings, shafting, and armor, but have no suitable forging machinery for heavy pieces of steel.

Mr. MORGAN. What is the weight of the largest steel casting that has been made by the Cambria Company? What are the weight and dimensions of the largest steel ingot that the Cambria Company can hammer or roll with its present machinery?

Mr. J. MORGAN, Jr. We have made castings of steel up to 15 tons weight. We can now, if required, make castings up to 30 tons; and a very slight change in our plant will enable us to bring the product of all three furnaces into one ingot, which will give upwards of 45 tons of steel. We roll, daily, ingots weighing 2½ tons, and this weight might be increased, say 10 to 15 tons, in our new blooming mill. As our largest hammer is but of 7 tons weight we have never attempted large steel forgings. We feel quite confident the hammers heretofore used upon

steel, in this country, have been too light, and the large forgings have not been satisfactory.

Mr. MORGAN. What is the ordinary percentage of phosphorus, sulphur, and silicon in the steel made by the Cambria Company from the ores taken from its mines?

Mr. J. MORGAN, Jr. The ordinary run of Bessemer steel is:

	Carbon.	MN.	SI.	S.	PH.
Rail	.30	.90	Trace to .03	.06	.09
Soft	.05	.40	Trace.	.04	.05

These are made from our own pig of *ordinary Bessemer* quality.

The ordinary run of open hearth steel is:

	Carbon.	MN.	SI.	S.	PH.
Spring steel	.80	.60	.08	.05	.075
Soft	.10	.30	Trace.	.03	.04

These are made from our own pig of *our own selected ores.*

Our special open-hearth steel from metal dephosphorized in washing furnace:

	Carbon.	MN.	SI.	S.	PH.
Spring steel	1.10	.25	.05	.02	.02
Soft	.05	.20	Trace.	.02	.02

Mr. MORGAN. What do you consider the highest percentage of each of these ingredients that is admissible in steel, suited for guns of high power and for ship plates and ship armor?

Mr. J. MORGAN, Jr. The quality we call special open hearth should be used in gun metal and armor plates, or phosphorus and sulphur should be each below .03 and silicon below .05. For ship plates, these grades are unnecessarily pure; and phosphorus .06 to .08, sulphur .05, silicon .10, will give qualities fully up to the present Government specifications of physical qualities, which qualities are certainly good enough.

Mr. MORGAN. Does the Cambria Company use, or has it used, any method of washing iron with iron oxide to eliminate the phosphorus? State with what success this has been done, and whether it is a costly process. Any facts you may state in this connection will be interesting and valuable in this investigation, as tending to show whether, and by what means, metal that has an excess of phosphorus can be relieved of it so as to make good steel.

Mr. J. MORGAN, Jr. The Cambria Company has in use a dephosphorizing process, which consists in washing the molten pig metal in a basic hearth of iron oxide; about three-fourths of the phosphorus can be removed. It is a process which will pay for making a high grade of steel. We have washed continuously, for some months, several thousand tons of various grades. The commercial success of the process depends upon the relative cost of very pure and moderately pure ores, or pig, at the manufacturing point.

Mr. MORGAN. Please to describe in a general way the open-hearth rotary furnaces, used in the Cambria Works for making steel, and state what advantage there is in making open-hearth steel in such furnaces.

Mr. J. MORGAN, Jr. The Pernot, or rotary, furnaces have already been mentioned. Each consists of the regenerative parts of a Siemens open-hearth furnace. The melting bed is a shallow cylindrical pan, revolving about its vertical axis. The axis is slightly inclined, which gives a a deep bath of metal on one side and a shallow bath on the other. The effect of rotating the bed is to cause the molten bath to flow around and across the hearth, thoroughly stirring it. The advantage of this rotation is that the deoxidation is quicker, and that the gases are better worked out of the bath than can be done in a stationary hearth. The furnace also has the advantage of a hearth and ports that are quickly and easily repaired.

Mr. MORGAN. You have seen the basic process of making steel so as to eliminate phosphorus. What is your opinion as to the practicability of making large quantities of metal with that process in several furnaces, so as to get from all a good and homogeneous steel? Can this basic process be used to advantage in the Bessemer converter, either stationary or rotary?

Mr. J. MORGAN, Jr. I have seen the basic process at work in many Bessemer works; it has also been tried in the open hearth, but not to any considerable extent, and I am not fully conversant with the experiments in that direction; in the present state of my knowledge I should prefer to work the ordinary, or acid, open-hearth furnace, and get stock of the requisite purity by selection or some previous purifying process. If the question means "would I undertake to combine the products of several basic converters into one ingot, to get a good, sound, and homogeneous ingot," I would answer no. The basic process can be used to advantage in the Bessemer converter, for ordinary products, where the price of pig is favorable. The common difference of price of converting by acid and basic processes is from $2 to $3.50 per ton of ingots, depending on price of labor and materials. The basic process therefore requires a cheaper pig than ordinary Bessemer.

Mr. MORGAN. What iron and steel works in England or Europe have you recently examined?

Mr. J. MORGAN, Jr. In order to answer intelligently the questions of the Gun Foundry Board relative to the manufacture of gun and other heavy forgings, I visited many of the principal iron and steel works in Great Britain, Westphalia, Belgium, and France. Also several manufactories of guns and shops considered advanced in steel construction during a four months' tour in those countries. These included Welsh, Middlesboro, Sheffield, and Cumberland districts, in Great Britain.

Mr. MORGAN. What conclusions have you reached as to the relative advantages of the steam hammer and the hydraulic press or forge in working large masses of steel into guns or shafts or other heavy manufactures?

Mr. J. MORGAN, Jr. I am clearly of the opinion that steam hammers of large size must give way to the hydraulic forging press for guns, shafting, and armor plates.

Mr. MORGAN. What would be the comparative cost of a steam hammer of 100-tons weight of blow or impact, and a hydraulic press of equal power?

Mr. J. MORGAN, Jr. In a hammer, the work done depends on the velocity of a falling weight, and the pressure exerted on the material upon the space traveled by falling parts of the hammer; it being brought to rest,

much of the energy of the hammer is wasted in knocking itself to pieces. Both the large hammers at St. Chamond and Creusot are single acting, as their experience leads them to believe that a large mass falling slowly penetrates the steel further than a lighter tup driven by steam at higher velocity.

Calculations involving the comparison of hammers of different weights, and with different steam pressures used on top of pistons to give different velocities, involve many difficulties in getting data correctly. The question can only be settled practically; and an authority in whose judgment and knowledge I have the utmost confidence assures me that a press of 2,500 to 3,000 tons equals in forging capacity a 100-ton hammer. I am convinced of this from my own observation of the forging-press and the two heaviest hammers in existence. Taking, therefore, a 100-ton hammer as against a 3,000-ton press, it may be said that the hammer is much more costly in the first place—say from 50 to 100 per cent. more—and the repairs would be greater.

Mr. MORGAN. Could such a press be built at the Cambria works with suitable tools, and could such tools be made there?

Mr. J. MORGAN, Jr. We have the necessary information to build such a press at the Cambria works, with all its appurtenances.

Mr. MORGAN. What are the advantages of fluid or liquid compression in casting heavy ingots or other shapes of steel?

Mr. J. MORGAN, Jr. The advantage of fluid compression is to make the ingot more solid or free from blow-holes. It has been applied with advantage at Whitworth's, England, and at Aboukhoff, Russia. It is possible some other means may be found to accomplish the same result. The only one known to me at present is a large sink-head.

Mr. MORGAN. Can this method of hydraulic compression be relied upon to remove occlusions of gas from large masses of steel in casting?

Mr. J. MORGAN, Jr. How far this fluid compression can be relied on to produce this effect every time and how many failures there are in the operation, I had no opportunity to find out.

Mr. MORGAN. How does it compare with the method of stirring or rabbling the molten metal in a rotary open-hearth furnace in respect of freeing the metal from blow-holes?

Mr. J. MORGAN, Jr. Rabbling in the furnace can only remove the gas from the bath there. It may form in tapping or in the ladle or in the mold.

Mr. MORGAN. What would be the chief difficulty in using the method of liquid compression upon a casting of, say, 100 tons?

Mr. J. MORGAN, Jr. I consider the chief difficulty in fluid compression to be the great cost of the apparatus and the costly molds required to stand the pressure. An ingot of 100 tons would be about 65 inches in diameter and 21½ feet long. You can judge that the mold would be costly to safely hold the molten material under great pressure.

Mr. MORGAN. In making a steel casting for a gun of 50 or 100 tons, would you prefer Bessemer or open-hearth steel, and why?

Mr. J. MORGAN, Jr. I would prefer to make a casting of 50 to 100 tons of open hearth steel. There would be great difficulty in getting 50 to 100 tons of Bessemer steel ready to pour, all at the same time. It would take three 17 or five 10-ton converters for a casting of 50 tons, and six 17-ton converters for one of 100 tons, with engines sufficient to blow all these heats at once, in order that all the material might be of about the same temperature when poured. If some heats were cold and some hot they would not mix well. Aside from this difficulty the open-hearth steel, of same carbon, and made from same pig, is more

ductile than Bessemer. This proceeds from the fact that it requires less manganese, that it is less gaseous, and makes a more solid ingot. It is more homogeneous.

Mr. MORGAN. If Congress should furnish a market for a considerable number of guns of the heaviest known patterns, say fifty, to be built within five years, and for other guns of less power, and for ship plates, and armor plates, and engines for twenty first-class steel war ships, could the Cambria works do the entire work of providing the necessary material of the best quality, with its present financial abilities? Could the material be furnished from the iron ores, manganese ores, fluxes, and fuel of native production in the United States? Could all the tools needed for the work be made at the Cambria works?

Mr. J. MORGAN, Jr. I assume fifty guns of very high power would cost at least $5,000,000 and would weigh 5,000 tons. Twenty large vessels would probably each cost about $2,000,000, and require 6,000 to 8,000 tons of material, or the total amount of the contract would be $45,000,000 and 200,000 tons of material—about $9,000,000 and 40,000 tons material per annum. I believe Cambria is financially able to handle a contract of that amount. It is far below our present tonnage. This, I think, is the best evidence that can be given of our financial ability to handle a large contract. The material can all be made from ores, fuels, and fluxes produced in the United States. All the tools needed can be made in the United States. As machine tools are a specialty and would be needed soon, we would not undertake to make these in our own shops. We could buy them of American tool builders.*

The CHAIRMAN. Have you any tools or implements for the manufacture of guns similar to those cited in the Gun Foundry Board's report, pp. 40 to 44?

Mr. J. MORGAN, Jr. We have no plant for the manufacture of guns or heavy forgings, beyond the furnaces for melting the steel to cast into ingots.

The CHAIRMAN. Can you manufacture such tools equal in power, at the cost mentioned therein, and how much time would you require to furnish them?

Mr. J. MORGAN, Jr. We have estimated upon the cost of such tools, after a careful examination of the subject, and the estimate of the Gun Foundry Board is a close approximation for a plant of the size given. Such a plant would require two or three years to build and get into active operation. We have sufficient information to build such a plant, and the tools for the forging of guns.

Mr. MORGAN. How do our machine tools compare in design and workmanship with those you have examined in other countries?

Mr. J. MORGAN, Jr. In design and workmanship, the tools of several American builders are equal or superior to any to be had abroad. The special class of tools needed for gun work has not received attention here, because there has been no market for them. They are different from lathes and machines already built here only in being very large and powerful, and specially adapted to gun work. Large tools for marine engine work already exist in this country, and would only require duplication. Some very fine and well-built tools of American build are in the machine-shops, now doing a heavy class of work in this country.

The CHAIRMAN. Have we the material, plants, and experience required to produce any quality, dimensions, and quantity of steel suitable for the construction of modern armored vessels and the fabrication of modern heavy ordnance?

* See page 132. (Chairman.)

Mr. J. MORGAN, Jr. We have the material; we have not the plants, nor as yet all the experience necessary. Nor can we get the experience till we work the plants. I believe we will succeed in producing material of the quality and dimensions required.

Mr. MORGAN. Do you know of any fact that stands in the way of our capacity to build our own guns of high power, and our own ships entirely from material to be found in the United States?

Mr. J. MORGAN, Jr. I know of nothing to prevent our building guns of high power except the lack of forging capacity. The building of a forging plant requires a great outlay of money, and there must be some guarantee that such a plant will have profitable work before manufacturers will build it. Both these guns and all material for our ships can be made from ores, fuels, and fluxes which exist and are now worked in the United States. Vessels have been built of steel throughout, of American design, material, and workmanship, not inferior to the best done abroad.

Mr. MORGAN. And do you know of any want of skill or ability amongst American mechanics and engineers to prevent the work from being as well done here as it could be done in any foreign country?

Mr. J. MORGAN, Jr. There has been a lack of demand for such vessels at prices that would pay American constructors to build them, but no want of skill or ability among American mechanics or engineers to compass any work and do it as well as it can be done in any foreign country.

Mr. MORGAN. What is now the annual production, in tons, of steel of all descriptions, at the Cambria works; and how much of each description is annually made at said works?

Mr. J. MORGAN, Jr. The annual production of ingots, with a good market, can be carried up to 240,000 tons with present facilities. The quantities of steel marketed are somewhat less, as there is waste of material in the subsequent processes of manufacture.

We have a possible output of 120,000 tons steel rails; 36,000 tons wire rods; 40,000 tons merchant steel; total, 196,000 tons.

Mr. MORGAN. Please to give analyses of the steel ores most generally used in the Cambria works.

Mr. J. MORGAN, Jr. We use for making our special steels a very pure ore, mined in the Lake Superior region, at the Cambria Iron Company's mines, on the Menominee Range, Michigan. For rail steels, we mix these ores with the Springfield and Bloomfield hematites, mined by the company in Blair County, Pennsylvania. These hematites were used in making Rodman guns some years ago.

The Menominee ores analyze:

Kind of ore.	Iron.	Phosphorus.	Sulphur.	Silica.
	Per cent.	*Per cent.*		*Per cent.*
Cyclops	61.68	.02	None	6.21
Vulcan	60.59	.03	None	6.58
Quinnesec	62.18	.04	None	7.69
Norway	55.62	.06	None	9.65

For special pigs, to be low in phosphorus, we use all Cyclops ore, which gives pig containing not more than .04 to .05 per cent. of phosphorus, and from which, by washing in the dephosphorizing furnace, we can make a pig containing .01 to .008 phosphrus.

The CHAIRMAN. In the manufacture of steel, to what chemical and mechanical tests do you subject it?

Mr. J. MORGAN, Jr. We subject the steel to chemical analysis to determine its purity, and to physical tests to determine its physical qualities.

The CHAIRMAN. By whom is this done?

Mr. J. MORGAN, Jr. This is done in our chemical and physical laboratories by experts in those branches.

The CHAIRMAN. What testing machine do you consider the most effective for the work required in the production of suitable steel for war vessels and heavy ordnance, and your reasons therefor?

Mr. J. MORGAN, Jr. After some experience with lever machines, we have ordered an Emery machine as the most accurate and durable. As we have not yet put it to work, we have no experience with it. My reason for believing it to be the most accurate and durable is that it is without knife-edges to wear, and thereby alter the performance of the machine.

The CHAIRMAN. By what method can the Government best be supplied with guns and armor?

Mr. J. MORGAN, Jr. I believe the Government can be best served by such liberal encouragement to steel manufacturers as would induce them to build plants to forge the gun material. I think the Gun Foundry Board's view of this matter is a good one, viz., to buy the forgings from private manufacturers and do the finishing and assembling at Government shops. It must be remembered that the large plant required to forge guns can only be employed in the speciality of heavy steel forgings, and no one can enter this business without the security of a contract of large size. On the other hand, to secure the Government, the payments to private parties should only be for accepted material that has passed the required test.

The CHAIRMAN. What is your opinion of the comparative cost of supply (*a*), wholly in Government works; (*b*), partly in such works and partly by contract with private builders, or (*c*), wholly in private works?

Mr. J. MORGAN, Jr. In answering this question I can only base my opinion on the history of the art of to-day. The only Government heretofore supplied exclusively from its own factory is the Russian, which makes ingots and forgings and finishes guns at Aboukhoff. According to newspaper reports it has recently given Krupp an order for 2,000 guns. This seems to be an evidence of the failure of supply from the Russian Government works. Again, the Woolwich Arsenal has totally failed to supply England with artillery equal to modern requirements. The English nation to-day depends for large gun-forgings upon Whitworth alone. Armstrong, Cammell, Vickers, and others are, however, rapidly developing forging-plants. The supply from private establishments in England, now that the Government is willing to use steel and buy it, will soon be equal to the demands of the Government. The arsenal will make up the guns as fast as the material can be furnished. These two failures of Government establishments may be studied in comparison with the present condition of the French nation, which has two magnificent private forges, viz., Le Creusot, with a 100-ton, and St. Chamond, with an 80-ton hammer. The Creusot works is the only concern so far that has produced a steel armor-plate. The French Government, with the most splendid artillery in Europe, have made most of it within the last ten years, forging it in private forges, and finishing it in the Government shops. This system has worked well. The only first-rate power in the world supplied wholly by private makers is Germany. I incline to the opinion that the large guns forged by Krupp under his small 40

or 50 ton hammer will not equal the French forgings, and that his heavy guns are inferior to the French. As he finishes the guns, however, there must be less opportunity to carefully examine the forged parts than if the material passed out of his hands. As to relative cost of methods *a*, *b*, and *c*, I think the Government would not make a steel ingot so economically as a private works. Making, say, from ten to twenty thousand tons of ingots per annum, they would not be able to provide the raw material so cheaply as an establishment producing ten times as much, and labor being confined to gun ingots only would be more expensive per ton, and the losses for waste necessary to the working and making of large ingots only would be greater. For the present I believe the method *b* would be the cheapest for the Government, for the reason that the heavy and costly finishing tools necessary could only be provided with work upon guns, and a private establishment would require a very generous price to put down such a plant. After a private establishment had developed the forging business sufficiently and had acquired such a reputation that they could sell guns abroad, as Krupp and Armstrong do, there would be more temptation to put in a gun-finishing plant.

The CHAIRMAN. In case of divided labor, how should the division be made?

Mr. J. MORGAN, Jr. One works should forge and rough-turn and temper, and the other finish the gun. The division can best be made at the delivery of the rough turned and tempered forging. In turning an examination and inspection of the soundness of the forging can be made. Physical and chemical examinations of the material can be made at the same time, so that reasonable assurance can be given that material accepted is sound and of proper quality.

The CHAIRMAN. Where do you consider the best location for such a method of production?

Mr. J. MORGAN, Jr. For military reasons the location should not be upon the exposed seaboard, where a foreign enemy might seize it by a sudden attack. The plant to produce ingots and forgings should be located where fuel and raw material are reasonably cheap and where there is a supply of labor skilled in steel working and metallurgical operations. I would accept the locations selected by the Gun Foundry Board for gun-finishing plant for the reasons given in their report, that if the question of selection of a site is opened local jealousies will delay the arming of the Army and Navy.

The CHAIRMAN. Is there any reason why the steel manufactured in the United States should not be restricted to the manufacture of home material?

Mr. J. MORGAN, Jr. I can see no objection except the fact that restriction might be a disadvantage to those in position to import foreign ores or pig to their own advantage.

The CHAIRMAN. Can any works in the United States with present plant produce any grade of steel that would probably be called for by Government specifications for guns and armor equal metallurgically to foreign?

Mr. J. MORGAN, Jr. I believe the Cambria Works can with ores produced in this country make steel equal in purity to any needed for guns or armor.

The CHAIRMAN. Under existing conditions what will be the additional cost of such steel as compared with the foreign of the same quality laid down in the United States free of duty?

Mr. J. MORGAN, Jr. The records of the Government ought to show the price abroad; American manufacturers should be paid more.

The CHAIRMAN. By what process would you make, and to what treatment would you subject, steel for modern heavy guns, armor-plate, and plates for boilers and ships?

Mr. J. MORGAN, Jr. The only steel now considered suitable for guns and armor and boiler plate is that made by the open-hearth process. Forging should be done by the hydraulic press. The manufacture of armor is now an open question, but I think it will eventually be decided in favor of a plate compounded of hard and soft steel. For large and thick plates the use of steel means a more powerful forging press than any yet built to put the necessary work on the material.

The CHAIRMAN. In the production of such steel, with equal care of manufacture, can as good results be obtained by washing, &c., medium and poor ores as with the best selected material?

Mr. J. MORGAN, Jr. I do not think good results can be obtained by the use of the poor ores. The average of good Bessemer ores are too high in phosphorus for gun material. From a good Bessemer pig, by puddling or washing, an excellent low phosphorus stock, suitable for gun metal, can be made. Results can be obtained in this way equal to any obtained by selected ores. We have to deal with phosphorus in the blast-furnace coke as well as in the ore, and unless dephosphorized stock is made, very expensive pig must be used.

The CHAIRMAN. Do you consider proximity to natural gas an advantage to the steel manufacture?

Mr. MORGAN, Jr. The natural gas is undoubtedly of some advantage if the supply is good and reliable.

The CHAIRMAN. What is your opinion as to its comparative reliability, sufficiency, safety, cost, and purity with other fuels?

Mr. MORGAN, Jr. As to its reliability and sufficiency, it may be said there are wells existing that have given off gas for many years. No doubt the experience with oil wells will be repeated with gas wells; wells have failed and will cease to flow. To keep up the supply of gas new ones must be drilled and new territory developed. The gas is an excellent fuel of great purity; it is as safe to handle as a steam boiler. Care is needed to avoid accident. Considering the cost of drilling wells and maintaining pipes it is probably little cheaper than coal in many localities.

The CHAIRMAN. Is it found in large supply in the vicinity of your works?

Mr. J. MORGAN, Jr. It is found within forty miles of our works, and proposals have been made to pipe us a supply.

The CHAIRMAN. Are there any forges in the United States capable of properly forging steel shafts for ships of more than 1,500 tons, and parts of modern ordnance heavier than 6-inch caliber?

Mr. J. MORGAN, Jr. I do not consider anything less than a fifty-ton hammer can do justice to steel in forgings of the sizes needed for large guns and shafting, and for the largest guns, one of one hundred tons should be used.

The CHAIRMAN. Are there any rolls in the United States of sufficient capacity to roll armor-plate of more than 2-inch thickness?

Mr. J. MORGAN, Jr. Judging from what is done by the mills now making compound plate abroad, armor thicker than 2 inches might be rolled here.

The CHAIRMAN. Where is the boundary between iron and steel?

Mr. J. MORGAN, Jr. The words wrought iron and steel are now com-

monly used in this country to distinguish fibrous metal made by puddling or some bloomary process, which is wrought iron, and a crystalline malleable metal made by casting the fluid metal, which is called steel. A grade of steel is also made by a puddling process which is an exception to the above definition. There is no absolute boundary-line between iron and steel. Both are compounds or alloys of iron with small quantities of other elements of various kinds and variable amounts. This question has been discussed at length by many experts.

The CHAIRMAN. At what stages of the manufacture are blow-holes formed?

Mr. J. MORGAN, Jr. Gases are doubtless present in steel at all times. Their collection in visible cavities during solidification produces blow-holes, so called.

The CHAIRMAN. Could all the parts of a 100-ton steam hammer be manufactured in the United States?

Mr. J. MORGAN, Jr. Undoubtedly they could be made in the United States, and as well as anywhere.

The CHAIRMAN. How is steel tempered, and why is oil generally used instead of other fluids?

Mr. J. MORGAN, Jr. Steel is hardened by sudden cooling from a high heat. This is done in various ways, and it is tempered by slightly heating it again. Ordnance and armor are, I believe, universally tempered by dipping them into an oil bath. Oil is used because its action is not so sudden as water, and there is less risk of cracking the steel.

The CHAIRMAN. Why is not petroleum used?

Mr. J. MORGAN, Jr. If a petroleum oil of high fire-test is selected, I see no reason why it should not be used. Ordinary petroleum is a mixture of oils, including some that are very volatile. If ordinary petroleum was used it would evaporate rapidly or probably burn. Linseed or cotton seed oils stand a higher temperature before igniting.

The CHAIRMAN. In what way is the quality of the steel improved by working and treatment?

Mr. J. MORGAN, Jr. Forging, if properly done, increases the density of steel and changes the character of the metal as shown in the fracture from a coarsely and irregular crystalline to a fine and uniform texture. If by treatment you mean oil-hardening, this raises the elastic limit and ultimate strength of materials. Subsequent annealing is intended to make the piece of uniform hardness and take out local strains from the sudden cooling or hardening.

The CHAIRMAN. Is the density increased?

Mr. J. MORGAN, Jr. The density is increased by forging; hardening slightly decreases the density.

The CHAIRMAN. In what part of the United States are the most suitable ores to be found for the manufacture of guns and ship steel?

Mr. J. MORGAN, Jr. In all the large iron or steel producing districts the ore is brought to the coal. I do not see that the ore locality determines the proper point of establishing Government or private manufactories. Good steel ores are found in large or small deposits in many widely separated localities, from the Atlantic to the Pacific coast. The cost of haul to the fuel determines their value.

Mr. MORGAN. Please give a record of tests of your steel.

Mr. J. MORGAN, Jr. The following table contains a tensile test report of various brands of Cambria steel:

[Collated for the Select Committee of United States Senate on Ordnance and War Ships. C. A. Marshall, engineer of tests.]

Tests of various brands of Cambria steel.

[Cambria Iron Company. Testing laboratory report. Tensile test (special). Johnstown, Pa., February 7, 1885.]

Brand.	Dimensions of cross section.	Carbon. Per cent.	Elastic limit, pounds per square inch.	Ultimate strength, pounds per square inch.	Elongation in 8". Per cent.	Reduction of area. Per cent.	Modulus of elasticity, pounds per square inch.	Appearance of fracture.	Remarks.
Bessemer, special soft	⅞" ϕ	.04	36,270	55,800	28.5	52.5	.....	Silky	All standard tests on ⅞" round as from rolls.
Do	⅞" ϕ	.10	35,240	61,170	25.7	50.9	.....	....do	
Bessemer, soft wire	⅞" ϕ	.08	40,530	60,800	26.1	47.0	.....	....do	
Do	⅞" ϕ	.15	45,250	68,820	23.3	45.0	.....	....do	These all made between December 1, 1884, and January 15, 1885.
Bessemer axle	⅞" ϕ	.19	49,030	75,180	22.2	42.0	.....	....do	
Bessemer machinery	⅞" ϕ	.25	52,480	80,370	20.2	38.6	.....	Part silky	
Bessemer toe calk	⅞" ϕ	.29	56,040	89,250	19.1	38.0	.....	Crystalline, dull center	
Bessemer knife back	⅞" ϕ	.35	61,900	98,310	19.2	33.5	.....	....do	
Rail, average of week ending December 6, 1884.	⅞" ϕ	.32	61,385	95,897	17.6	28.2	.....	.....	
Open-hearth special soft	⅞" ϕ	.07	28,670	49,320	32.4	65.1	.....	Silky	Standard test on ⅞" round as from rolls.
	⅞" ϕ	.07	29,140	49,090	31.4	65.9	.....	....do	
Open-hearth boiler plate	⅞" ϕ	.14	36,380	55,690	31.3	55.3	.....	....do	Standard test.
	⅞" ϕ	.14	36,820	56,360	27.1	55.3	.....	....do	
Open-hearth boiler plate, same heat as above.	1¾" x ⅝"	.14	38,950	58,660	28.0	52.8	.....	....do	From plate lengthwise.
	1¾" x ⅝"	.14	37,560	58,510	28.6	53.7	.....	....do	Do.
	1¾" x ⅝"	.14	37,640	56,350	26.1	47.1	.....	....do	From plate crosswise.
	1¾" x ⅝"	.14	37,140	56,280	28.2	48.6	.....	....do	Do.
Open-hearth ship plate	⅞" ϕ	.19	41,420	65,540	24.7	47.8	.....	....do	Standard test.
	⅞" ϕ	.19	41,430	65,250	25.9	50.7	.....	....do	
Open-hearth ship plate, same heat as above.	1¾" x ⅝"	.19	40,540	64,630	24.5	50.4	.....	....do	Tests by United States Government inspector.
	1¾" x ⅝"	.19	43,690	66,180	25.0	46.9	.....	....do	
	1¾" x ⅝"	.19	40,130	65,460	26.6	51.6	.....	....do	
	1¾" x ⅝"	.19	41,950	65,680	24.9	49.3	.....	....do	
Open-hearth bridge tension	⅞" ϕ	.25	45,450	72,350	22.0	41.9	30,450,000	Silky	Standard test.
	⅞" ϕ	.25	45,930	72,870	23.5	42.5	.....	....do	Do.
Open-hearth axle and machinery steel.	⅞" ϕ	.28	48,930	80,090	21.3	38.9	.....	....do	Do.
	⅞" ϕ	.28	48,790	79,680	21.1	37.0	.....	....do	Do.
Open-hearth bridge compression.	⅞" ϕ	.34	52,280	85,570	19.1	33.8	30,750,000	....do	Do.
	⅞" ϕ	.34	52,600	85,330	21.2	34.0	.....	Silky and part crystalline	Do.
Toe calk	⅞" ϕ	.36	52,470	88,260	19.5	34.2	.....	Part crystalline, part fiber	Do.
	⅞" ϕ	.36	53,140	88,490	20.5	40.5	.....	....do	Do.
Knife back	⅞" ϕ	.37	59,510	99,040	17.3	39.6	.....	....do	Do.
	⅞" ϕ	.37	59,500	97,790	18.0	35.9	.....	....do	Do.
Fork	⅞" ϕ	.70	59,500	113,300	12.8	19.0	.....	Crystalline, dark spot	Do.
	⅞" ϕ	.70	60,270	111,500	10.9	14.0	.....	....do	Do.

Tests of various brands of Cambria steel—Continued.

Brand.	Dimensions of cross section.	Carbon. Per cent.	Elastic limit, pounds per square inch.	Ultimate strength, pounds per square inch.	Elongation in 8″. Per cent.	Reduction of area. Per cent.	Modulus of elasticity, pounds per square inch.	Appearance of fracture.	Remarks.
Spring	¾″ ϕ	.75	71,270	133,000	5.9	7.4	.....	Crystalline, dark spot	Standard test.
	¾″ ϕ	.75	70,890	131,900	6.8	7.9	.....	....do	Do.
Do	¾″ ϕ	1.06	87,180	150,400	2.5	4.0	.....	....do	Do.
	¾″ ϕ	1.06	87,180	157,600	3.3	4.0	.....	....do	Do.
Special high	¾″ ϕ	1.05	82,580	146,900	5.7	9.2	.....	Very fine crystalline	Do.
Open-hearth carbon	¾″ ϕ	1.05	82,810	145,400	5.5	9.2	.....	....do	Untempered.
from same heat	¾″ ϕ	1.05	118,600	202,250	6.2	20.6	.....	....do	Oil tempered.
Gautier cold, polished steel	¾″ ϕ	.....	69,770	86,480	9.7	39.6	29,810,000	Part dull crystalline, part silky	Specimens turned from 1¼″ round.
Do	¾″ ϕ	.....	69,960	87,860	6.5	36.0	28,930,000	Silky	
Gautier special, cold polished steel	1″ ϕ	.....	78,630	106,370	*In 10″* 8.4	36.0	29,740,000	Dull crystalline, duller center	1″ round not turned.
Do	¾″ ϕ	.....	83,070	105,630	*In 8″* 9.0	42.9	28,450,000	....do	¾″ round not turned.

All specimens tested as rolled, untempered, unless otherwise noted.

STATEMENT OF MR. ROBERT H. LAMBORN.

NEW YORK, *December* 16, 1884.

GENTLEMEN: I am not now an officer of the Colorado Coal and Iron Company, but as former managing director, and as the officer under whose care the iron and steel works were planned and brought into operation, I may give you the following general information:

Pueblo, where the works are situated, is 650 miles from Ogden, which is 880 miles from San Francisco, a total of 1,530 miles from the Pacific navy-yards, 2,000 miles nearer than New York, so that steel can be laid down at San Francisco at, say, 1,600 miles less freight than from the Pittsburgh region, where it is produced cheapest. Pueblo, at 1 cent per ton per mile, has an advantage of, say, from $15 to $20 per ton over eastern locations.

As to material for the manufacture of steel, the mines of the Colorado Coal and Iron Company produce in ample quantities *the best steel* making ores. There are from 600,000 to 800,000 tons in sight at one mine, the analysis of which I will send you, all of which would make cutlery steel.

The Crested Butte Mines, 200 miles west of Pueblo, on the railroad to California, are now producing 75 tons of coke per day for Utah; 25 additional coke furnaces will go into operation next month, which will give 112 tons of coke per day. It is equal to the best Connellsville or English coke, and is the only very good coke west of the Mississippi.

The iron works consist of a blast furnace on the most substantial plan, 65 feet high; Bessemer steel converting works capable of producing, say, 300 tons per day; a first-class rail-rolling mill; first-class puddle furnaces (Siemens); a first-class rail-mill; bar, spike, and splice works, and foundry.

Excellent refractories and fluxes are found on the property, and the company makes its own spiegeleisen from Colorado ores.

The tests made so far show that the iron and steel are equal to the best made in the East.

Yours, very truly,

ROBERT H. LAMBORN.

To the Select Committee, &c.

NEW YORK, *December* 23, 1884.

ROBERT H. LAMBORN, Esq., *City:*

DEAR SIR: In reply to your inquiries, beg to inclose such information as I have near at hand. As I expect to return in a few days to Colorado, shall be able to gather further information, which I shall take pleasure in furnishing you.

I remain, yours, truly,

HENRY E. SPRAGUE,
President Colorado Coal and Iron Company.

MAGNETIC ORE.

[Calumet in 1883 produced 22,689 tons.]

	Analysis made at the Edgar Thomson Steel Works.	Company's analysis.	Company's analysis.
Metallic iron	62.397	65.80	64.49
Silica	6.290	5.78	5.10
Phosphorus	.0019	.015	.004
Sulphur	.396	.014	.055
Lime	trace.	.34	
Alumina	1.550	1.50	
Manganese	.110	.22	.06
Magnesia	1.978		
Phosphoric acid	.0045		

HEMATITE ORE.

[Hot Springs in 1883 produced 14,895 tons.]

Metallic iron	57.30	59.20	
Silica	5.03	3.41	
Phosphorus	.019	0.021	
Sulphur	.006	.008	
Manganese	1.87	1.11	

COAL MINES.

The output of the several coal mines was as follows:

	Tons.
Cañon mines	170,312
Cuchara mines	82,391
Cameron mines	5,298
El Moro mines	277,577
Crested Butte mine	63,539
Total	599,117

Analysis of coals, coke, iron ore, and limestone.

COALS.

Cañon coal:		Per ct.	Per ct.
Water		4.50	5.49
Volatile matter		34.20	39.33
Fixed carbon		56.80	51.01
Ash		4.50	4.17
		100.	100.
Sulphur		—	.35
Cuchara coal:		Four-foot seam.	Seven-foot seam.
Water		3.23	2.97
Volatile matter		40.93	40.08
Fixed carbon		49.54	48.67
Ash		6.30	8.28
		100.00	100.00
Sulphur		.62	.65
El Moro coking coal:			
Water	0.26	1.66	1.34
Volatile matter	29.66	34.48	35.79
Fixed carbon	65.76	60.08	54.75
Ash	4.32	3.78	8.12
	100.00	100.00	100.00

Crested Butte coking coal (bituminous):

	Per ct.	Per ct.
Water	1.10	.44
Volatile matter	23.20	24.17
Fixed carbon	72.60	72.30
Ash	3.10	3.09
	100.00	100.00
Theoretical yield of coke	75.70	75.39

Crested Butte (anthracite):

	Three-foot six-inch seam.	Six-foot seam.
Water and volatile matter	5.17	6.29
Fixed carbon	90.65	89.89
Ash	4.18	3.82
	100.00	100.00

Irwin (anthracite):

Water and volatile matter	3.15
Fixed carbon	93.93
Ash	2.92
	100.00

COKES.

El Moro coke:

Fixed carbon	87.47
Ash	10.68
Water and volatile matter	1.85
	100.00
Sulphur	.85

Crested Butte coke:

	Per ct.	Per ct.	Per ct.
Water and volatile matter	1.35	.42	.41
Fixed carbon	92.03	90.71	92.44
Ash	6.62	8.87	7.15
	100.00	100.00	100.00
Sulphur		.58	.37

STATEMENT OF MR. WILLIAM METCALF.

PITTSBURGH, PA., *December* 10, 1884.

Mr. MORGAN. Please to state your profession and how long you have been engaged in its pursuit. If you are a manufacturer of steel, which class of production do you make?

Mr. METCALF. I took the degree of civil engineer at the Rensselaer Polytechnic Institute, Troy, N. Y., in 1858. I immediately entered the Fort Pitt Foundry, Pittsburgh, first as draughtsman and assistant engineer; I was made superintendent of the shops in one year; was put to the study of iron, especially that adapted for guns, and in 1862 was placed in entire charge of the manufacture of guns, including the selection and purchase of the iron; I remained in that position, or in the discharge of the same duties, until late in the year 1866, when I abandoned the foundry business and joined the firm of Miller, Barr & Parkin, owners of the Crescent Steel Works. I am still in the same concern, now known by the firm name of Miller, Metcalf & Parkin.

Our business is the manufacture of crucible cast steel of all grades, and the conversion of Bessemer and open-hearth steel billets into such commercial shapes as our patrons require.

Our specialty is the manufacture of the finest grades of crucible cast steel. The following is an enumeration of a few of the uses to which our steel has been successfully applied:

Rolls for the mint, for cold-rolling bars of the precious metals for coining. Dies for stamping coin. Dies for stamping jewelry, some of which have been very intricate and difficult shapes. Drills for rock-drills, used at Hell Gate and in some of the most difficult iron, copper, and gold mines in the country. Lathe tools and machine tool cutters of the most irregular and difficult shapes. Large drills and reamers for boring oil wells: Some of these bits have weighed as much as 500 pounds each and have been used for drilling holes through rock 18 inches in diameter. Fine sheets for cutlery, saws, clock springs, and such work. Cold-rolled steel for the finished parts of sewing-machines, keys, ladies corsets, shoe shanks, watches and clocks, watch springs, and for innumerable other little articles. Cold-hammered drill wire for drills, graving tools, punches, watches, and many other small purposes.

The cold-rolled and cold-hammered steels are finished to great accuracy and are measured by micrometers to the thousandth of an inch; sight bars for the national armory are rolled to exact dimensions, not varying more than one-quarter of one-thousandth of an inch from the required size.

For astronomical purposes our steel has been cold-rolled to $\frac{1}{7000}$ of an inch in thickness.

Mr. MORGAN. Name the steel-producing establishments in and around Pittsburgh, the number and description of steel furnaces in each estab-

lishment, and their respective present per diem (24 hours) capacity for making steel.

Mr. METCALF:

Name of firm or company.	Apparatus.	Capacity.	Remarks.
Bessemer steel.			
Carnegie Bros. & Co., Limited	Two 10-ton vessels and two 4-ton vessels.	700 tons, about	Operate the Edgar Thomson Steel Works and the Pittsburgh Bessemer Steel Works.
Oliver Bros. & Phillips	One 2-ton fixed converter for special steels.	40 tons, about	
Open-hearth steel.			
Park, Bro. & Co., Limited	Two furnaces	67 tons, net	Black Diamond Steel Works.
Hussey, Howe & Co., Limited	do	55 tons, net	Double turn.
Linden Steel Company, Limited		75 tons, net	
Spang Steel and Iron Company, Limited.		40 tons, net	
Singer, Nimick & Co., Limited		20 tons, net	
Mackintosh, Hemphill & Co., Limited.	Two 7-ton furnaces		
Shoenberger & Co	Two furnaces	50 tons, gross	Juniata Iron and Steel Works.
Crucible cast steel.			
Pittsburgh Steel Casting Company.		175 tons,* gross	
Hussey, Howe & Co., Limited		35 tons, net	
Park, Bro. & Co., Limited		33 tons, net	
Brown & Co		32 to 35 tons	
Miller, Metcalf & Parkin		43 tons, gross	
Smith, Sutton & Co		32 tons	La Belle Steel Works.
Singer, Nimick & Co., Limited		62 tons, net	
Anderson, Du Puy & Co			
Cassidy & Co			

*Including Bessemer.

Mr. MORGAN. Are hydraulic presses or forges used in any of these works, and do any of them use hydraulic power for the liquid compression of steel?

Mr. METCALF. No; I do not know of such hydraulic presses being in use anywhere in the United States.

Mr. MORGAN. What is about the heaviest steel ingot that can be successfully handled?

Mr. METCALF:

Name of company or firm.	Description of hammer.	Remarks.
Linden Steel Company	4-ton	Adapted to hammering an ingot 12 inches square.
Pittsburgh Steel Casting Company.	5-ton	Adapted to hammering an ingot 9 inches square.
Shoenberger & Co	5-ton	Can hammer a 1-ton ingot.
Smith, Sutton & Co	4½-ton	Adapted to hammering an ingot 20 inches square.
Hussey, Howe & Co	30-cwt	Adapted to hammering an 800-pound ingot.
Singer, Nimick & Co	4-ton	Adapted to hammering an ingot about 16 inches square.
Park, Bro. & Co	17-ton	Adapted to hammering an ingot 45 inches diameter.
Brown & Co	5-ton	
Miller, Metcalf & Parkin	3-ton, nominal	Has hammered ingots 18 inches diameter.

It must be borne in mind that these sizes of ingots are all given for solid sections, and any hammer could work effectively a ring whose walls were as thick as the thickness of the ingot named. A hammer capable of hammering an ingot 12 inches square is of such power that that is the thickest mass it would hammer with a certainty of doing good work.

As a reduction of one-half is ample to secure good, sound work, such a hammer would finish bar, slab, ring, or any other forging 6 inches thick when finished. The width and length would be governed only by the size of the dies and the working room around the hammer. It is my opinion that Park, Brother & Co.'s hammer is as efficient as Krupp's noted 50-ton hammer, as the latter is nothing but an open-top steam pile-driver, while Park's hammer is a closed-top steam-hammer. I do not say that any of these establishments are in complete shape to make the heaviest gun forgings, but I do say that the hammer is the most expensive and most important part of the plant, and that the hammers quoted are all good up to the limit given.

I have added the following question: Is the liquid compression of steel by hydraulic power desirable?

I am unable to see what use there can be for liquid compression by machinery in the manufacture of guns when the Government owns the right, for which it paid half a million dollars, to use Rodman's method of liquid compression by controlling the cooling of the mass so as to produce the desired compressive strains in the most effective direction. Many years of practice and study have demonstrated to me that all properties of cast iron and cast steel are common to both substances, or, in other words, both substances are controlled by the same laws. Cast steel is nothing but clarified cast iron; it contains less of carbon, silicon, phosphorus, sulphur, or other impurities than cast iron. All properties of cooling, shrinking, chilling or hardening, and tempering or annealing are common to both, varying only in degree and in the temperatures which cause the display of these different properties.

The compression given by hammering and the fineness of texture can be secured by sudden cooling, and so directing the cooling from the interior as to bring the strains in the right direction. If the first cooling were insufficient, subsequent heatings and coolings could be resorted to cheaply and effectively.

All of the advantage of liquid compression could be obtained by casting a high head on the piece; and in the case of a gun this could be done at almost no cost, because such high heads would be long tubes, which, when cut into rings of proper weight, would be precisely what is wanted by the makers of locomotive tires. Therefore, there would be practically no waste.

A Rodman cast-iron gun is almost strong enough for rifling, and guns to resist the strain of the powder behind a rifled projectile could be made of cast iron easily. Such guns would not resist the wear of the projectiles on the lands of the bore, neither would they afford good hold for securing the movable parts of a breech-loading gun. If such a gun could be made of a uniform tensile strength of 60,000 pounds per square inch, it would be amply strong for rifling. That such a gun can be produced by the Rodman system there can be little doubt to me. The difficulties in the shape of suitable molds, suitable core barrels, blow-holes, &c., are no greater than were encountered and overcome by the first makers of the Rodman cast-iron guns. Most of them have been overcome already, notably the blow-hole business by the Terre Noire

process; and I would call your attention to the fact that, no matter what may be said about the failure of the Terre Noire people to make guns, it is a fact that they have never tried the Rodman plan; they have merely removed the most serious difficulty in the way of its trial—blow-holes.

Accompanying letters show that ingots up to 25 tons weight can be cast by existing plants.

If one 10-ton gun can be made in this way, thousands can be made with more certainty than by any known process of hammering or machine compression.

If a 10-ton gun be made this way, then a 100-ton or a 200-ton gun can be made as easily by the enlargement of plant.

Rodman's system made the United States the most powerful nation on earth, and stimulated all Europe to vast outlays to produce the guns of to-day, none of which are certain in their qualities.

The same plan could be thoroughly tested in steel at a cost not to exceed $100,000 for the production of one moderate-sized gun. The success of one such gun—and the success or failure could be demonstrated inside of a year—would settle the whole gun question; and in case of success every open-hearth plant in the country would then compete for the Government patronage.

Mr. MORGAN. Is the metal used in making steel in the works you have named made from native or foreign ores?

Mr. METCALF. From native ores almost exclusively; if foreign ores are used, it is only on account of price.

Mr. MORGAN. In your manufactory of fine steel for tools and the like do you use American or foreign iron, and do you make your own steel? If you use both, please state in what proportions.

Mr. METCALF. We use both American and foreign iron. The reason we use foreign iron is that American manufacturers have not found time to make iron with the care that is used in Sweden, because the Swedes cannot make cheap iron; therefore, they must make exceptionally good iron in order to sell it. Americans can make cheap iron; therefore, they do not devote themselves to a small output of fine quality. Still, I believe that nine-tenths of the fine steel that is produced in America is made from American iron made from American ores. We make our own steel exclusively. I have visited a large number of the iron mines of Sweden and America, and have tested and had analyzed the ores and irons made from them. I say positively and of my own knowledge that we have in America ores, in practically inexhaustible quantities, that are quite as good in every respect as any ores that are to be found in Sweden, or, I believe, anywhere in the world.

Mr. MORGAN. You know the qualities of steel adapted to making guns of high power, steel ships of war, and ship armor. Please state whether Pittsburgh, with proper furnaces and machine tools, could supply the Government of the United States with all the metal, made from American ores, needed for such purposes for its full defense on land and water.

Mr. METCALF. Pittsburgh possesses the largest aggregation of plant, and the most thoroughly organized and skilled labor in abundance, of any place in the country. Skill in producing and manipulating heavy masses is the leading characteristic of her people.

You are already answered in regard to hammer capacity; in regard to plates—

Name of firm or company	Remarks.
Shoenberger & Co.....	Can roll and trim a plate 100 inches wide, 1 inch thick, and 175 inches long.
Park, Bro. & Co	Three high plate mill has top and bottom rolls 32 inches in diameter and 115 inches long; the middle roll is 22 inches in diameter; the greatest opening is 14 inches. Allowing 8 inches for reduction, this mill will turn out, just as it stands to-day, plates that will finish to 90 inches wide by 6 inches thick by any length that might be needed. If the middle roll were taken out, which could be done in a few hours, and the train were run two high, it would then have an opening of 36 inches. Allowing 18 inches for reduction, it would turn out a finished plate 18 inches thick, 90 inches wide, and as long as the table could carry. Mr. Park would not say how many tons, but he said if he had a chance he would keep on trying until he stalled his engine. If any one says 18 inches is not enough reduction for an 18-inch plate, I have no opinion to offer; but surely no one will say that from 36 inches to 9 inches would be insufficient, and you still have a mill that is ready now to make 9-inch armor.* Probably a demand for extra-heavy armor would involve the remodeling or building of some heating furnaces, but no concern would hesitate about that if a respectable order were offered.
Singer, Nimick & Co	Can roll plates 80 inches wide, any thickness up to 6 inches, and length governed by weight.
Hussey, Howe & Co.....	Can roll a plate 81 inches wide, 200 inches long, and ¾ inch thick.
Spang Steel and Iron Company.	Can roll plates up to 30 feet long by 100 inches wide by 1 inch thick.
Smith, Sutton & Co	Can roll a plate 22 inches by ½ inch by 20 feet long.
Pittsburgh Steel Casting Company.	Largest plate 26 inches wide, 10 feet long, 9 inches thick.
Brown & Co.....	Largest plate 125 inches by 50 inches by 1 inch.
The Linden Steel Company	Can roll plates 78 inches wide and any reasonable thickness and length.

* See page 322. (Chairman.)

There are four or five equally powerful plate mills in our iron works, and one or two more steel mills, whose owners have not reported. The above dimensions are present maximum capacities. It is not overstating it to say that Pittsburgh could turn out easily 1,200 tons of heavy plates per day with her present mills.

Mr. MORGAN. What is about the annual production of iron in and around Pittsburgh?

Mr. METCALF. Total rolled iron, including nails, 472,351 net tons; pig iron, 592,475 net tons.

Mr. MORGAN. Is there any want of good fuel, good material, and good workmen in and around Pittsburgh for the manufacture of the machine tools of the best and heaviest description, to be worked by either steam or hydraulic power?

Mr. METCALF. None whatever; nearly all of our best plants have been fitted out in Pittsburgh shops, especially in the heavier machinery, excepting, of course, special machines which are made in various parts of the country, one adapted to one particular piece of work, and another to another.

Mr. MORGAN. Please to state the extent to which natural gas is employed in boiler and furnace work as fuel, and your opinion, with any data you choose to give to support it, as to the probable continuance of a full supply in the future.

Mr. METCALF. Natural gas is now used for raising steam, puddling and heating iron, melting, heating, and annealing steel, for making glass, and for domestic purposes. It is used very largely, and must continue to be used in the future. Good wells twenty to forty years old are already known, and its permanence seems as well assured as that of oil. In a few years not many great wells will be found, but the sup-

ply will be kept up and increased by hundreds of small and more permanent wells. There is a limit to its quantity, but what that limit is no one can tell; if it should fail, the next best fuel-producer, gas, can be made here cheaper than in any other place in the world. The best of gas fuel can be laid down on our producers for from 50 cents to $1 per ton. There is enough natural gas being wasted now every day to supply probably the whole present need of Pittsburgh; it has been escaping in this way for nearly twenty years, in larger or smaller quantities; and any one who is familiar with the country must be well assured of at least half a century's supply.

Mr. MORGAN. State what advantage, if any, there is in the use of natural gas in respect to the quality of the metal it is used in producing or working, and in respect to the saving of time and expense over good coal or coke.

Mr. METCALF. My experience is limited to steel. A high, soft, penetrating heat can be obtained more easily and safely in a natural-gas flame than in any other. It is precisely such a heat as is essential to thorough and good work on large masses of steel, and for this reason alone it would be justifiable to pay twice as much for natural gas as for coal in working very heavy masses; but in fact the gas is the cheaper fuel. The difference in time is not very great, but the safety of it in skilled hands is of much real value.

Mr. MORGAN. Is there any known fact that renders this natural gas unfit for melting metal in cupolas or otherwise preparing it for making Bessemer steel?

Mr. METCALF. It is not adapted to cupola practice at all; a solid fuel is a necessity in a cupola. There is no reason why metal may not be melted for Bessemer purposes by natural gas; but in a rail mill or other strong running plant the coke would probably be the most efficient. Later discoveries, as we learn to use the gas, may change all this.

Mr. MORGAN. What is the comparative cost of producing Bessemer steel with the use of coke as fuel, and open-hearth steel with natural gas as fuel, at Pittsburgh, and which, in your opinion, would be the better metal?

Mr. METCALF. It is claimed that Bessemer steel can be made for $2.50 less per ton than open-hearth steel. This difference could be diminished by the difference in price between coal and natural-gas. The question of quality is difficult and delicate. As users of both and makers of neither, our experience has been that the difference is trifling; in some little characteristics we prefer the Bessemer, for others we prefer the open-hearth, and for general purposes we use them indifferently. It is with these products as with everything else under the sun, that is the best which is produced with the largest percentage of conscience.

Mr. MORGAN. Please state any other facts or opinions that you think would throw light on these subjects.

Mr. METCALF. It is a fact that Pittsburgh is the best market in the country for the purchase of material.

As to the relative qualities of the guns produced in Pittsburgh, Reading, and Boston, I refer you to the records of the Bureau of Ordnance.

It is a fact that Pittsburgh is the best labor market in the country. Our skilled men are more largely Americans than in most other places; they have the inherited faculty of handling large masses and tackling large problems. They are intensely loyal and law-abiding and are well organized. In 1877, after the railroad officials and militia from other places had begun to play with fire and had run away, our city was in

a state of anarchy and had just eighty-two policemen. The great mass of our loyal, law abiding mill men permitted the destruction of the railroad and prevented the destruction of other property. There is no safer place in the country for invested capital than in a Pittsburgh mill.

The transportation facilities of Pittsburgh by rail and by water are unrivalled. It is stated that in the year 1880 the commerce of Pittsburgh was greater than the commerce of New York City; the census records will show whether this is true or not.

As a matter of opinion, if the Government can only find out what it wants, and it will make those wants known, the men will be found who will supply them. The Rodman gun, the monitors, and the Mississippi jetties, were all supplied by energetic civilians, who gave them to the Government just at the right time. The Government will certainly be sustained and supplied again by her own citizens just as soon as her ideas are dragged out of chaos and formulated into something tangible.

I have no interest whatever in either heavy armor or guns except as an American citizen. I never want to see another gun, so I write freely, wishing to give you all the information that is possible. The concern with which I am connected is entirely out of the line of such work, and, for myself, I have had enough of it, and like to think of the gun business as belonging to the dead past. Having, then, no interest to serve, I shall be glad to answer any questions that may interest you or be of benefit to Pittsburgh, so far as I may be able.

[Brown & Co., Wayne Iron and Steel Works.]

PITTSBURGH, *December* 10, 1884.

DEAR SIR: Appreciating the intent of you inquiries of the 9th instant, we beg to reply as follows:

Our daily maximum capacity of crucible cast-steel ingots is between 32 and 35 tons.

Fitted with a ladle and other minor appliances, we could cast an ingot of over 13,000 pounds.

Our heaviest hammer is 5 tons—heavy enough, we should say, to hammer thoroughly a 1-ton ingot.

We have never tested our plate mill in the way of *maximum* thicknesses; the aim has always been to the other extreme. As a safe venture, we would put our maximum plate as 125 by 50 by 1 inch.

Trusting these answers will suffice,

We are, very truly, yours,

BROWN & CO.

WILLIAM METCALF, Esq.,
Miller, Metcalf & Parkin, City.

[The Spang Steel and Iron Company, Limited.]

PITTSBURGH, PA., *December* 10, 1884.

DEAR SIR: In reply to yours of 5th, on behalf of the Senate select committee, I would say:

Our daily capacity, in pounds, of ingots is 80,000.

The heaviest ingot we can cast is 20,000 pounds.

We have no hammer.

We can roll plates up to 30 feet long by 100 inches wide by 1 inch thick.

Yours, truly,

R. FORSYTH,
Superintendent.

WILLIAM METCALF, Esq.,
Miller, Metcalf & Parkin.

[Park, Brother & Co., Limited.]

PITTSBURGH, PA., *December* 8, 1884.

DEAR SIR: We are in receipt of your favor of 5th instant, and in reply would say, when our crucible melting furnaces are all in order we can make 83 net tons of crucible ingots per day.

In our open-hearth furnaces, under the same conditions, we can make 67 tons per day.

Our heaviest hammer is one of 17 tons drop and will thoroughly hammer an ingot 45 inches diameter.

We can roll a plate, say, 110 inches wide by 60 feet long, and from 1½ inch up to 1½ inches thick.

Yours, truly,

PARK BROTHER & CO., LIMITED,
WM. G. PARK, *Chairman.*

WILLIAM METCALF, Esq., *City.*

[Singer, Nimick & Co., Limited.]

PITTSBURGH, PA., *December* 6, 1884.

DEAR SIR: Our daily capacity, in pounds, in ingots of any quality, is 124,960 crucible, 40,000 pounds open-hearth. The heaviest ingot we can cast is 4,500 crucible, 20,000 open-hearth. The weight of our heaviest hammer is 8,000 pounds. It will hammer thoroughly an ingot about 16 inches square. The largest plate we can roll is 80 inches wide, length according to thickness, and can roll up to 6 inches thick.

Trusting the above will be satisfactory,

I remain yours, truly,

W. H. SINGER,
Chairman.

WILLIAM METCALF.

[Juniata Iron and Steel Works.]

PITTSBURGH, *December* 9, 1884.

DEAR SIR: In reply to your favor of 5th instant, we are able to produce 50 tons of steel ingots per day of any quality.

If necessary we could cast a slab up to 25 tons in weight, by pouring the output of our two furnaces into one mold, but with our present cranes and machinery we could not handle a slab and put it through our mill weighing over 7,500 pounds.

The weight of our heaviest hammer is 5 tons, enabling us to hammer thoroughly an ingot weighing 1 ton.

The largest plate we can roll and trim is 175 inches by 100 inches by 1 inch.

Yours, truly,

SHOENBERGER & CO.

WILLIAM METCALF, Esq., *City.*

[Hussey, Howe & Co., Limited.]

PITTSBURGH, PA., *December* 6, 1884.

DEAR SIR: Our daily capacity in ingots of any quality is 170,000 pounds.

The heaviest ingot we can cast is 20,000 pounds.

Our heaviest hammer is 30 cwt.

It will hammer thoroughly an ingot weighing 800 pounds.

The largest plate we can roll would be 81 inches by 200 inches by ¼ inch.

Yours, truly,

HUSSEY, HOWE & CO.

WILLIAM METCALF, Esq., *City.*

[The Pittsburgh Steel Casting Company.]

PITTSBURGH, PA., *December* 6, 1884.

DEAR SIR: Yours of 5th instant received, making inquiries for use of the Senate select committee, to which we reply as follows:

Daily capacity, 175 tons of 2,240 pounds each.

Heaviest ingot, 25 tons (limited by capacity of crane, which could be increased to 100 tons or more).

Hammer weighs 5 tons; will hammer thoroughly an ingot 9 inches square.

Largest plate we can roll, 26 inches wide, 10 feet long, 9 inches thick.

Yours, very respectfully,

PITTSBURGH STEEL CASTING COMPANY,
JOHN IRWIN, JR., *Treasurer.*

Mr. WILLIAM METCALF, *City.*

[La Belle Steel Works.]

PITTSBURGH, PA., *December* 6, 1884.

DEAR SIR: In reply to your favor of 5th instant, say that our present capacity on crucible steel is 32 tons daily. We could cast an ingot of 5 tons. Our heaviest steam-hammer is 4½ tons, and we can hammer on it a 20-inch square ingot, and do so thoroughly.

The largest plate we could roll would be about 22 inches by ½ inch and 20 feet long.

Yours, truly,

SMITH, SUTTON & CO.

WILLIAM METCALF, Esq.,
Messrs. Miller, Metcalf & Parkin, City.

[Linden Steel Company, Limited.]

PITTSBURGH, PA., *December* 6, 1884.

DEAR SIR: In answer to your inquiry of 5th instant, we beg to say that our daily capacity, in pounds and in ingots, is 150,000 pounds. The heaviest ingot we have cast is 4,000 pounds; we could, by preparing for same, cast a full heat of 30,000 pounds. Our hammer is called a 4-ton hammer, but we have not tried larger than a 12-inch ingot on it. We can roll plates 78 inches wide, almost any reasonable thickness, and we think as long as any one.

Yours, very truly,

LINDEN STEEL COMPANY, LIMITED,
HENRY LLOYD, *Vice-President.*

WILLIAM METCALF, Esq.,
Messrs. Miller, Metcalf & Parkin, City.

[Carnegie Brothers & Co., Limited.]

PITTSBURGH, *December* 10, 1884.

DEAR SIR: Replying to the inquiries in your favor 5th instant—

First. Our daily capacity of ingots, of quality suitable for rails, is about 1,568,000 pounds, or 700 gross tons.

Second. We can, if necessary, cast an ingot weighing 30 gross tons.

Third. Our heaviest hammer is one of 8 tons, and it will hammer a 16-inch ingot.

Fourth. The largest plate which we can roll is 36 inches wide, 7 inches thick, length from 30 to 70 feet, according to thickness.

Yours, very truly,

CARNEGIE BROTHERS & CO., LIMITED,
H. M. CURRY, *Manager.*

Mr. WILLIAM METCALF,
Miller, Metcalf & Parkin, City.

MIDVALE STEEL COMPANY.

STATEMENT OF MR. R. W. DAVENPORT.

PHILADELPHIA, PA., *November* 21, 1884.

Mr. MORGAN. Please state your name, residence, and occupation.

Mr. DAVENPORT. R. W. Davenport. I reside in Philadelphia, and am the superintendent of the Midvale Steel Company's works, Nicetown, Philadelphia, Pa.

Mr. MORGAN. What is the present capacity of that establishment in producing steel of all kinds?

Mr. DAVENPORT. About 1,500 tons a month.

Mr. MORGAN. How many furnaces have you?

Mr. DAVENPORT. Three melting furnaces.

Mr. MORGAN. Siemens furnaces?

Mr. DAVENPORT. Yes. By far the largest part of our steel product is melted by what is known as the Siemens-Martin, or open-hearth, process; a small amount of special steel being produced in crucibles. We have, at the present time, three open-hearth furnaces, in which about thirty-five tons of steel can be melted at one time. This will enable us to cast an ingot of sufficient size to make the heaviest single part, namely, the tube or jacket of a 12-inch steel rifled gun. A traveling crane is now in course of construction to serve the three furnaces above mentioned, which will enable us, at an early date, to cast the ingot referred to.

Mr. MORGAN. What is the principal business that that establishment is now engaged in?

Mr. DAVENPORT. In the manufacture of locomotive and car-wheel tires, locomotive and car axles, miscellaneous forgings, rolled and hammered merchant steel for tools, springs, and machine purposes, and, during the last two years, a considerable amount of ordnance work.

Mr. MORGAN. What description of ordnance work have you been doing?

Mr. DAVENPORT. In the spring of 1877 we were first asked by the Navy Department to furnish some short tubes for reinforcing Parrott guns. These tubes were successfully manufactured, and the test specimens taken from the same fully met the requirements.

A long, soft tube and a harder jacket were made in 1878 for the conversion of a smooth-bore Dahlgren gun into a 9-inch rifled gun. A number of howitzer forgings have also been furnished to the Navy from time to time. In the spring of 1881 the steel parts of the Haskell 6-inch multicharge gun were fabricated. These consisted of a forged tube and breech extension piece, and unforged solid castings for the four powder-pockets.

We heard nothing further from the Government until the spring of 1882, when Captain Sicard, the chief of Bureau of Ordnance, United States Navy, undertook the building of two 6-inch breech-loading rifle guns, which he wished to make entirely of American steel, the one to consist of a tube, jacket, and hoops; the other, of a tube and jacket, with the hoops replaced with steel wire wound on.

The Midvale Company undertook to make the forgings of all the parts of these guns according to the specifications laid down by the

Bureau, and, after considerable experimenting, succeeded in meeting all requirements. The hooped gun was completed about a year ago. We forged the parts and sent them to the Washington navy-yard, where they were machine-finished and assembled. The gun was subjected to the firing test at Annapolis early last spring, and stood a large number of trial rounds satisfactorily. The above was, I believe, the first cannon above 3-inch caliber made entirely of American steel.

When work on the above-mentioned experimental guns was well under way, and it had been demonstrated that the material could be produced of the quality required, it was decided to build more guns of the same kind, and an order was placed with us for the parts of eight 6-inch and two 5-inch hooped guns, to be used in arming the new cruisers. Later, to complete the armament of the Chicago, twelve more 6-inch guns were required, and we again contracted to make the steel for the same. This work is now in hand.

In July, 1883, the Ordnance Board of the Army undertook the construction of a steel, rifled field-piece of $3\frac{2}{10}$ inches caliber. The various parts required were given to us to make, and the quality of the metal, as shown by the tests, proved satisfactory. The piece has been lately completed at the Watertown Arsenal, and has, I believe, given excellent results in firing.

At about the same time the Ordnance Department of the Army contracted with us for the manufacture of some of the steel parts of various pieces of heavy ordnance, which it had planned to construct. These were principally the hoops for a 12-inch mortar, which was to have a cast-iron body; the hoops, breech-blocks, &c., for an all-steel rifled gun, of 8-inch caliber, the tube and jacket for which had been ordered abroad, as our facilities were not equal to their production; also, a number of hoops, rings, &c., for a wire-wound gun with cast-iron body, and, later, the steel hoops for a cast-iron bodied 12-inch rifle.

Most thorough tests of all the above-mentioned steel parts have been made on the Government testing machine at Watertown, and the results have in general been so satisfactory as to elicit a very complimentary notice of the work done at Midvale by the Chief of Ordnance in his annual report for the present year, and to leave no doubt that the material is well suited to the construction of high-power guns, and that such material can be now furnished at these works with uniformity and certainty, up to the capacity of our present plant.

I may also mention that we have just contracted with the Army Ordnance Department for the furnishing of fifty steel tubes to be used in converting 10-inch cast-iron, smooth-bore guns into 8-inch rifles. These conversions have heretofore been made with coiled wrought-iron tubes, as made by the West Point Foundry Association, at Cold Spring; but last spring the Midvale Company made a trial tube of steel for this purpose, which proved, in testing, so satisfactory that it was determined to take advantage of the saving of expense effected by the use of steel over wrought iron, and to make the conversions, planned for the coming year, with steel.

We are now in hopes that the Chief of Ordnance will see his way clear to the construction of another trial-type gun of 8-inch caliber, to be made entirely of American steel; and that he will ask proposals for the material from American manufacturers, as we are now engaged in increasing our facilities so as to be able to produce the forgings required for a gun of this caliber.

Mr. MORGAN. To what extent do you finish those parts you have been speaking of for the Navy?

Mr. DAVENPORT. At present we can only rough-turn and bore the hoops; and have not the necessary facilities for rough-boring and turning the tubes and jackets. The oil-tempering of the pieces has to be done after boring, and we therefore have arranged, in the case of the material furnished to the Navy, to send the rough forgings of tubes and jackets to the Washington navy-yard to have them rough-bored and turned there; they are then returned to us for treatment. After treatment, we cut test-specimens from each piece, as directed by the Government inspector stationed at these works; these specimens are tested by the ordnance authorities, and each piece is accepted or rejected on the results of the tests.

Mr. MORGAN. All the boring then of these tubes and jackets is done in Washington?

Mr. DAVENPORT. Yes; of all the tubes and jackets furnished to the Navy.

Mr. MORGAN. You have no facilities at the Midvale works for either boring or turning?

Mr. DAVENPORT. No, not for turning and boring pieces of any length, such as tubes and jackets. The lack of such facilities has been a great disadvantage to us. We have not procured such tools, partly because we have had no suitable shop in which to put them; and, also, because we know that no tools well adapted to the work have as yet been made in this country. An extension to our machine-shop is now being planned, with a view of there erecting lathes for boring and turning all the parts of heavy guns, together with ample crane facilities for handling the same.

Mr. MORGAN. When you say no such tools are made in this country, you mean of the size, not of the pattern?

Mr. DAVENPORT. There have, of course, been made numbers of boring and turning lathes, and some of them of great size, which have been used in making cast-iron ordnance; but for boring and turning steel economically much more power is required, both for driving the lathe and for feeding the tool, than is the case with cast iron, and we have not thought it advisable to put in any tools that were not as good as can now be made for the purpose for which they are intended.

Mr. MORGAN. Well, these lathes at Washington answer the purpose, do they not?

Mr. DAVENPORT. Yes, there are a large number of lathes there and in other shops, on which the work can be done, but not economically.

Mr. MORGAN. You have no idea that such tools could not be made in the United States?

Mr. DAVENPORT. Without doubt such tools can be made in this country. The development of such machines must, of course, be somewhat gradual. European makers have doubtless accumulated much valuable experience bearing upon the subject during the last ten or fifteen years. There are, however, in this country, tool-makers who are so skillful in tool-building, and who are so well posted as to what has been done elsewhere, that they can, without doubt, construct the tools as soon as they become familiar with the requirements of the work to be done on them, and as soon as a demand arises for such machines.

Mr. MORGAN. This oil-bath that you speak of—is that a process of tempering metal?

Mr. DAVENPORT. Yes; it tempers or hardens the metal, but it also breaks up a coarse, crystalline or irregular structure and renders a mass of steel more amorphous.

Mr. MORGAN. When did you build the tanks in which this tempering takes place?

Mr. DAVENPORT. Early last spring. We have had our oil-tempering tanks in operation about nine months. We have lately constructed, and have in successful operation, an oil-tempering plant where, with slight modifications, the largest parts of an 8-inch steel gun can be oil-tempered.

Mr. MORGAN. Do you use them for tempering these guns?

Mr. DAVENPORT. Entirely for that purpose.

Mr. MORGAN. I suppose the expense of transporting these guns to Washington and back is borne by the Government?

Mr. DAVENPORT. Yes.

Mr. MORGAN. Do you make the steel out of which you build these parts of guns, or cast these parts of guns, out of American material?

Mr. DAVENPORT. Not entirely; partly of American and partly of foreign material.

Mr. MORGAN. What is about the proportion of American material?

Mr. DAVENPORT. About one-half.

Mr. MORGAN. What description of material is that—pig-iron or blooms?

Mr. DAVENPORT. Mostly blooms.

Mr. MORGAN. Where from?

Mr. DAVENPORT. From the Northern New York or Lake Champlain district.

Mr. MORGAN. Where do you get the pig?

Mr. DAVENPORT. It is partly English and partly Swedish.

Mr. MORGAN. What is the cost of the Swedish pig?

Mr. DAVENPORT. About $40 a ton.

Mr. MORGAN. How much is it in England?

Mr. DAVENPORT. About $28 or $30.

Mr. MORGAN. What is the cost of blooms?

Mr. DAVENPORT. About $52 a ton.

Mr. MORGAN. You of course use spiegel and ferro-manganese?

Mr. DAVENPORT. We do.

Mr. MORGAN. Is the ferro-manganese an American production or foreign?

Mr. DAVENPORT. Both. Up to within about a year it was nearly all imported. It is now made at the Edgar Thomson Works, near Pittsburgh.

Mr. MORGAN. Have you used any of the New Jersey spiegel?

Mr. DAVENPORT. Yes, from time to time.

Mr. MORGAN. Is it good?

Mr. DAVENPORT. Very good.

Mr. MORGAN. Have you used any American metal that will make good open-hearth steel—make gun-metal, for instance, without mixture with foreign metals?

Mr. DAVENPORT. Yes; open-hearth steel of the highest quality can be produced from materials made entirely from American ores. High quality in steel depends, in great part, upon a low percentage of phosphorus in it; and, up to the present time, there have been found but few American ores which give a pig-iron very low in phosphorus. The blooms from Northern New York, however, of which I have already spoken, are most excellent in quality, and two processes have been introduced lately into this country, by either of which large quantities of material, low in phosphorus, can be produced. I speak of the "basic" Bessemer process, that has been successfully tried at the Pennsylvania Steel Works, at Steelton; and of the "Krupp" process for washing phos-

phorus from pig-iron, by melting it in an open-hearth furnace, on a bottom made of oxide of iron. This last process is being successfully operated by a firm at Youngstown, Ohio. We have analyzed and used some of their product, finding it very pure and suitable for making the highest grade of open-hearth steel.

Mr. MORGAN. The question of cost aside, could you assemble at Midvale all the material for making steel from the United States?

Mr. DAVENPORT. I think we could, undoubtedly.

Mr. MORGAN. Including spiegel, manganese, &c.?

Mr. DAVENPORT. Yes.

Mr. MORGAN. And in sufficient quantities to supply any demand the Government might make?

Mr. DAVENPORT. Undoubtedly.

Mr. MORGAN. Do you make chemical analyses of the steel you produce?

Mr. DAVENPORT. Yes; we make constant analyses of all our steel.

Mr. MORGAN. Do you mean you analyze every run?

Mr. DAVENPORT. Not completely. We determine carbon in every run; but, for gun work, a complete analysis of every heat is made. Every heat is tested before the forgings are made.

Mr. MORGAN. Physical tests?

Mr. DAVENPORT. Yes, sir.

Mr. MORGAN. I want to get the proportion of deleterious agents you leave in this steel when you make it.

Mr. DAVENPORT. There is, beside carbon and iron, not far from one per cent. of other substances.

Mr. MORGAN. You think you can find American ores in abundance that would yield steel with no greater percentage of foreign matter than that?

Mr. DAVENPORT. Without doubt, with the aid of the purifying processes already referred to.

Mr. MORGAN. Have you used the Lake Superior metal?

Mr. DAVENPORT. Very little.

Mr. MORGAN. Do you make the open-hearth of higher grade than Bessemer?

Mr. DAVENPORT. Yes; as a rule.

Mr. MORGAN. Returning to these pieces of guns that you make; do you hammer those guns in your establishment?

Mr. DAVENPORT. Yes. We have to date only forged tubes and jackets for six-inch all-steel rifled guns under our hammer; but, in our opinion, the same parts for eight-inch guns can be there successfully produced, and heavy power-cranes are now being constructed to replace our present cranes, with this end in view.

Mr. MORGAN. What is the power of the hammer?

Mr. DAVENPORT. Between 9 and 10 tons falling weight. There is steam admitted on top the piston, which largely adds to the force of the blow. It is of William Sellers & Co.'s make.

Mr. MORGAN. Are the pieces hammered solid?

Mr. DAVENPORT. Yes; the tubes and jackets are so hammered. The hoops, however, are hammered on a mandrel or are rolled. In rolling a hoop we make it in the same way as we do a tire. We have adapted our tire-mill to the rolling of steel rings 12½ inches wide for hooping large guns. We have now under consideration plans for increasing our rolling capacity so as to produce rings 24 inches wide.

Mr. MORGAN. Is there any preference between rolled and hammered hoops?

Mr. DAVENPORT. I think not. Experience so far shows rolled equal to hammered hoops. There is very little difference, if any. In the matter of *forging* gun-rings or hoops we have designed and now have in successful operation tools for the production of such hoops 18 inches wide and 30 inches in diameter, and could easily increase our facilities in this direction.

Mr. MORGAN. Do you ever practice liquid compression of metals?

Mr. DAVENPORT. No; and as regards such compression we cannot speak from actual experience; we can, however, say from the results of the tests made by the Government in our steels, that if proper precautions are taken in the melting of the metal, most excellent material can be produced for gun purposes *without* fluid compression. Its use, however, may possibly in the future be found desirable from an economical point of view.

Mr. MORGAN. You do not use hydraulic power?

Mr. DAVENPORT. Not in an extensive way as yet. We have some special machines driven by hydraulic power.

Mr. MORGAN. I suppose you have no special experience by which you could compare the value of a compressor having hydraulic force and the steam hammer?

Mr. DAVENPORT. Only by comparing tests of our material with those of material made at foreign establishments where they forge with a press instead of a hammer—as at the works of Sir Joseph Whitworth, for instance.

Mr. MORGAN. Have you done that?

Mr. DAVENPORT. The Army and Navy have a number of comparative results.

Mr. MORGAN. Personally, you have not made any?

Mr. DAVENPORT. No; I can only say that, as a rule, the results of tests of our metal compare very favorably with the tests of imported steel. Mention of this fact is made in this year's report of the Chief of Ordnance. As to the best manner of forging large masses of steel, we are of the opinion that a hydraulic press would be more efficient and more generally useful, as well as more economical, than a very large hammer. Such a press could be well adapted, we think, to the manufacture of solid steel armor plate.

The design and construction of this press would, of course, require considerable time and a large outlay of money. A much larger oil-tempering plant than that we now have would be necessary; the experience, however, which we have already had in this direction, would much facilitate the construction of a new plant.

Mr. MORGAN. Do you make boiler plate?

Mr. DAVENPORT. No; we have made steel blooms for boiler plate, but at present do not roll it ourselves.

Mr. MORGAN. Do you furnish any angle-iron to ship-builders?

Mr. DAVENPORT. No; we have never rolled any shapes for ship-building. We were, however, one of the first concerns to undertake the making of steel shapes, such as angles, channels, and beams; and we rolled about 10,000 tons of such material for the New York and Brooklyn bridge. All the material in the superstructure of that bridge was rolled at our place. Since then our melting capacity has not been such as to warrant a general business of the kind.

Mr. MORGAN. That was all steel work?

Mr. DAVENPORT. Yes, it was Bessemer steel made at Cambria, and delivered to us in the shape of steel blooms.

Mr. MORGAN. Do you make shafts for steamers?

Mr. DAVENPORT. We make miscellaneous forgings, and have made some steamship shafts, but nothing very large.

Mr. MORGAN. What is the largest shaft you have forged?

Mr. DAVENPORT. Our largest forgings have been for gun work. The tube for a 6-inch steel rifle is about as heavy as any forging we have ever made. We expect, however, with our new facilities, to make shafts up to ten tons in weight.

Mr. MORGAN. How much would you have to enlarge your present melting capacity to produce, say, 150 tons a day of melted steel?

Mr. DAVENPORT. To make 150 tons in 24 hours we would have to about double our melting capacity.

Mr. MORGAN. From that, though, you could not get a run of 150 tons at one time?

Mr. DAVENPORT. No, we could not. The largest ingot, however, which has been called for by the Gun Foundry Board is to weigh 100 tons; and we could obtain that weight in one run by adding three or four furnaces to our present plant.

Mr. MORGAN. In a single casting?

Mr. DAVENPORT. Yes.

Mr. MORGAN. What fuel do you use in making this steel?

Mr. DAVENPORT. We use semi-bituminous coal from the Clearfield district; and, for melting, a considerable amount of gas-coal slack.

Mr. MORGAN. Do you find any phosphorus in the larger anthracite coals?

Mr. DAVENPORT. There is generally but a small amount of phosphorus in the coals we use; and as the metal is not brought in direct contact with the fuel, the phosphorus is not absorbed by the steel.

Mr. MORGAN. How would it be in the Bessemer process?

Mr. DAVENPORT. During the operation of melting in the cupola the metal may absorb some phosphorus from the fuel.

Mr. MORGAN. The fuel you use is good for the purpose.

Mr. DAVENPORT. Yes.

Mr. MORGAN. Having no bad agents?

Mr. DAVENPORT. No, we get first-rate fuel if we pay enough for it.

Mr. MORGAN. And you can get any fuel you wish to use for making steel of high quality?

Mr. DAVENPORT. Yes.

The CHAIRMAN. You feel assured you can have capital necessary to increase your works at any time on suitable inducements?

Mr. DAVENPORT. I should think so. In this connection I may mention that the Midvale Company has made an informal proposition to the Gun Foundry Board, in which it proposed to make the necessary additions to its plant for the production of the rough bored, turned, and oil-tempered parts of guns, up to and including those of 12-inch caliber, in case a contract could be made with the Ordnance Departments of the Government for a definite amount of steel at a fixed price, to be delivered within a given time.

The CHAIRMAN. That is to say, in short, upon a reasonable contract you can put up the necessary plant?

Mr. DAVENPORT. Yes, we would probably undertake to do so. Such a plant, designed for the production of the parts of 12-inch guns, would be laid down with a view of increasing it in the future for heavier guns; and we are of the opinion that it is desirable to undertake the moderate sized guns, say up to 12-inch caliber, before building our ultimate plant for the production of the parts of as heavy a gun as of 16-inch caliber, or

100 tons. Certain parts, of course, of the first plant could be made so as to meet future requirements for heavier work.

Mr. MORGAN. What would be the length and caliber of a 100-ton gun?

Mr. DAVENPORT. Approximately, 44 feet long, with a caliber of about 16 inches.

Mr. MORGAN. Your company would not undertake to deliver guns to the Government entirely complete?

Mr. DAVENPORT. I think it would consider such a proposition, although our estimates, upon which our proposals to the Gun Foundry Board were based, only covered the production of the various parts of guns, rough bored and turned and oil-tempered. The same tools that would be provided for rough boring and turning might be used, in part, for finishing, but additional tools would be required, such as a rifling machine, additional lathes, &c., and increased crane facilities would also be needed, together with shrinking-pits for assembling the parts and shrinking them togother. These additions to the plant would, of course, add much to its cost, and we would only consider the making of the necessary outlay in case a sufficient amount of work, either in the shape of parts of guns rough bored and turned and oil-tempered, or as completed pieces, could be guaranteed to us by the Government within a specified time.

Mr. MORGAN. Well, the complete establishment to turn out the steel and manufacture the gun would be more economical, would save more money, would it not?

Mr. DAVENPORT. Yes; I think that the completed work could be more cheaply done at one establishment than in any other way. There may, however, be objections to this plan.

Mr. MORGAN. What are they?

Mr. DAVENPORT. The men who have given most study to the matter are the ordnance officers of the Army and Navy, and, in the design and construction of the guns, their knowledge and experience should be utilized and considered.

Mr. MORGAN. Suppose you had the advantage of all that in constant inspection and in testing the merits of the piece after it was finished?

Mr. DAVENPORT. Apart from other considerations, the execution of the work of constructing and finishing the guns can be done more cheaply, I think, by the same establishment that manufactures the material than by another.

Mr. MORGAN. The Army and Navy officers would apply the same tests as you would?

Mr. DAVENPORT. Under any circumstances we should expect to have the testing of the material done under the supervision of Army and Navy officers.

Mr. MORGAN. They would resort to the same tests you employ, chemical and physical?

Mr. DAVENPORT. The Government inspectors make no chemical tests, and the steel makers would not wish to be bound both by chemical and physical specifications. We undertake to furnish each piece of such metal as will show, in a number of specimens cut from the same, when tested on the Government machines, a specified tensile strength, elastic limit, per cent. of elongation and contraction; but the chemical composition is left to our own judgment.

Mr. MORGAN. If you were making guns now, as a commercial enterprise for foreign nations, would you apply the same physical tests as the Army and Navy officers do now?

Mr. DAVENPORT. Yes; we do now make many such tests, several in each piece during the course of manufacture; by them we are guided in obtaining, with certainty, the qualities required.

Mr. MORGAN. Of course, the drawings of the gun would be presented to you by the Government, and then you would make up the pieces and put them together, having them tested as you went along, and when you get your gun completed it would be as good perhaps as if made by an ordnance officer of the Army or Navy?

Mr. DAVENPORT. I see no reason why it should not be so, as the work would be done under constant supervision of the officers you refer to. I am not prepared to express it as my opinion, that the plan you suggest would, in all respects, be the best to follow. I merely wished to say that it would be perfectly practicable for the same establishment to furnish the steel and make the completed guns, and that it would probable cost the Government less money. On the other hand the establishment of the gun factories by the Government, as proposed by the Gun Foundry Board, would undoubtedly, at the outset, greatly expedite the work; would relieve the private manufactures of a considerable portion of the necessary outlay, and would in the future, after the first large, hurried demands of the Government are filled and private concerns have grown to a point where they can easily undertake the manufacture of the completed guns, serve as suitable shops for experimental work and for meeting demands in times of emergency.

Mr. MORGAN. What I wished to find out was, whether the American manufacturers have confidence in themselves that they could build as good guns, good ships, and good engines, as anybody else could build?

Mr. DAVENPORT. Of that I think, after due experience, there can be no doubt.

The CHAIRMAN. Mr. Jaques, do you wish to ask any questions?

Mr. JAQUES. If you were to advise the directors of your company as to whether they should enter into a contract with the Government to provide tempered material or the finished guns, which would you, as superintendent of the works, advise?

Mr. DAVENPORT. In my opinion, it would be best for my company to begin with the production of the rough bored and turned and oil-tempered material only; the problems to be solved in the successful manufacture of such material are numerous and difficult.

Mr. MORGAN. After the materials are prepared, the balance of the work to be done on the gun is entirely machine work?

Mr. DAVENPORT. Not entirely; besides the machine work, the parts must be shrunk together.

Mr. MORGAN. With that exception it is machine work?

Mr. DAVENPORT. Yes.

Mr. MORGAN. A man who could work the machine could put the gun together, could he not?

Mr. DAVENPORT. The same men would not do the two kinds of work. The shrinking would require specially prepared pits, furnaces, and cranes, and men trained to the work.

Mr. MORGAN. Which requires greater skill—bringing the material up to the perfected tube, or from that on to when the gun is finished?

Mr. DAVENPORT. The work is so different that comparison is difficult; there are, undoubtedly, much greater difficulties to be overcome in the production of the material, of the qualities desired, than in finishing the guns, and there are also much greater risks in the work.

WATERTOWN ARSENAL, MASSACHUSETTS,
August 14, 1884.

GENTLEMEN: I send inclosed copies of the records of tests of both Whitworth and Midvale steels.

These tests were made at this arsenal, on the Government testing-machine, in the ordinary course of testing work of the Ordnance Department, United States Army, required in the construction of experimental guns.

It will be seen from an examination of the record that specimens from the Whitworth 8-inch gun-tube give better results than those from the Midvale tube of the same caliber, but that the 8-inch hoops and 12-inch hoops from Midvale show higher qualities than either the tube or hoops from Whitworth.

F. H. PARKER,
Major, Ordnance Department, U. S. A., Commanding.

To the *Select Committee of the United States Senate on Ordnance and War Ships.*

RESULTS OF TESTS.

MIDVALE STEEL, FROM 12-INCH MORTAR HOOPS.

Marks.	Elastic limit (pounds per square inch).	Ultimate strength (pounds per square inch).	Elongation per inch after rupture.	Per cent. of contraction of area.	Character of broken surface.	
MB1$_1$	72,000	117,410	.1450	43.7	Silky, interspersed with fine granulations.	6-inch specimens.
MB1$_2$	72,000	117,810	.1888	43.7	Do.	
MB1$_3$	73,000	117,440	.17	47.2	Do.	8-inch specimens.
MB1$_4$	73,000	118,000	.1733	43.7	Do.	

WHITWORTH STEEL, FROM 8-INCH RIFLE TRUNNION HOOPS.

8-in. R, 1972	39,000	92,120	.1700	52.2	Fine silky.	6-inch specimens.
8-in. R, 1972	40,000	91,960	.1788	52.2	Do.	
8-in. R, 1972	30,000	76,000	.1733	47.2	Dull silky 60 per cent., fine granular 40 per cent.	

RESULTS OF TESTS—Continued.

MIDVALE STEEL, FROM 8-INCH RIFLE HOOPS.

Marks.	Elastic limit (pounds per square inch).	Ultimate strength (pounds per square inch).	Elongation per inch after rupture.	Per cent. of contraction of area.	Character of broken surface.	
RAz$_1$	62,000	107,280	0.1317	41.9	Fine granular, 60 per cent.; dull center, 40 per cent.	6-inch specimens.
RAz$_2$	62,000	107,200	.1667	41.9	Fine granular, 50 per cent.; smoky center, 50 per cent.	
RBz$_1$	58,000	103,280	.1600	39.2	Fine granular; smoky center.	
RBz$_2$	55,000	101,840	.1567	39.2	Fine granular; dull, smoky center.	
RB4$_1$	59,000	102,880	.1400	47.2	Fine granular; dull, smoky spot near center.	
RB4$_2$	59,000	104,440	.1317	39.2	Fine granular; dull spot near center.	
RA5$_1$	48,000	85,092	.1383	54.6	Silky, interspersed with fine granulation.	
RA5$_2$	51,000	90,240	.1367	57.0	Do.	
RA11$_1$	60,000	108,400	.15	39.2	Fine granular; dull center.	
RA11$_2$	59,000	108,600	.1150	27.6	Do.	
RB3$_1$	67,000	113,600	.1183	39.2	Do.	
RB3$_2$	62,000	110,000	.11	39.2	Do.	
RC4$_2$	66,000	115,160	.1367	39.2	Do.	
RCz$_2$	59,000	109,800	.12	36.4	Do.	
RAz$_3$	65,000	105,200	.1933	52.2	Silky, slightly granular.	3-inch specimens.
RAz$_4$	66,000	109,240	.1767	44.6	Fine granular; dull center.	
RBz$_3$	61,000	104,360	.1867	39.2	Fine granular.	
RBz$_4$	60,000	104,000	.1867	39.2	Fine granular; smoky spot near center.	
RB4$_3$	57,000	102,960	.1933	41.9	Fine granular; dull, smoky center.	
RB4$_4$	54,000	100,000	.1767	44.6	Do.	
RA5$_3$	60,000	98,920	.20	52.2	Silky, interspersed with fine granulation.	
RA5$_4$	60,000	100,400	.1767	47.2	Fine granular.	
RA11$_3$	63,000	108,000	.1666	39.2	Do.	
RB3$_3$	65,000	108,920	.1667	39.2	Do.	
RB3$_4$	70,000	111,160	.15	39.2	Do.	

MIDVALE STEEL, FROM 8-INCH TUBE.[a]

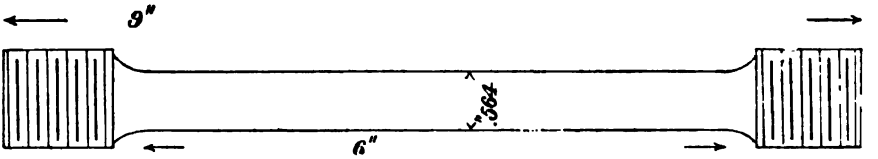
BT$_1$	38,000	79,086	0.20	27.6	Granular, 80 per cent.	3-inch specimens.
BT$_2$	35,000	79,600	.24	30.8	Granular, 60 per cent.; dull spongy spot, 40 per cent.	
BT$_3$	35,000	79,600	.24	33.6	Granular, 60 per cent.; dull spongy spot, 40 per cent.	
MT$_1$	41,000	82,400	.28	42.0	Dull spongy, slightly granular.	
MT$_2$	42,000	81,000	.237	30.8	Granular.	
MT$_3$	40,000	79,120	.26	42.0	Dull spongy, slightly granular.	
BL[T]	45,000	79,880	.307	56.8	Silky, spongy.	
BL[B]	40,000	78,480	.32	56.8	Do.	
BR$_1$	33,000	77,520	.20	30.8	Granular, 60 per cent.; dull spongy, 40 per cent.	
BR$_2$	35,000	75,920	.217	27.6	Granular. Small dull spot at circumference.	
MR$_1$	40,000	82,000	.18	39.2	Granular, 60 per cent.; dull spongy, 40 per cent.	

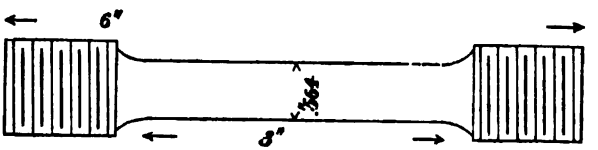
WHITWORTH STEEL FROM 8-INCH TUBE.*

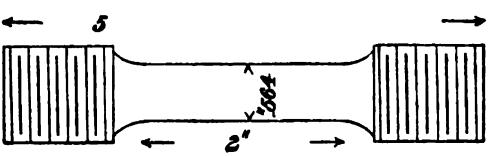
A	53,000	86,040	.2467	47.2	Silky, slightly granular.	3-inch specimens.
B	54,000	89,320	.24	47.2	Silky, irregular surface.	
C	44,000	84,000	.20	44.6	Silky.	
H	60,800	104,000	.21	44.6	Silky, slightly granular.	
I	52,800	93,280	.20	36.4	Fine granular.	
J	59,760	97,000	.1733	36.4	Do.	
P	53,000	100,569	.12	11.8	Granular.	2-inch specimens.
R	51,000	91,600	.20	36.4	Silky, 50 per cent.; granular, 50 per cent.	

*NOTE.—It is to be remarked that the Whitworth metal had been oil-tempered; while in the case of the Midvale 8-inch tube, the tube in its fabrication was not oil-tempered, but simply annealed, in accordance with the specifications of the contract under which it was made. This would account for the lower elastic limit, relative to the tensile strength in the Midvale metal as compared with the Whitworth. (CHAIRMAN.)

Forms of specimens.







LETTER FROM THE NORRISTOWN IRON WORKS.

NORRISTOWN, PA., *July* 28, 1884.

GENTLEMEN: Your circular of July 16 is received. We do not manufacture steel of any kind, or heavy iron for vessels; therefore cannot answer any of the questions in relation to those articles. We did make heavy iron plates for building the Canonicus, Napa, and Saugus during the late war, but have since disposed of our plant for that kind of work, and only make skelp iron for gas and water pipes, as well as the pipes. Our opinion as to the best points for the erection of works for the manufacture of guns or the building of iron vessels by the *Government* would be League Island, Philadelphia. If the vessels were to be built by private parties we think Roach's, of Chester, the best point. The materials can be brought to these places at a very low cost, on account of the competition of the different railroads, as well as the excellent water communication with all the iron and steel mills of Pennsylvania.

Yours truly,

JAMES HOOVEN & SON.

To the Select Committee, &c.

LETTER FROM THE OHIO IRON COMPANY.

[The Ohio Iron Company, manufacturers of pig, bar, hoop, and angle iron, light T-rail, and railway spikes.]

ZANESVILLE, OHIO, *July* 28, 1884.

GENTLEMEN: In response to your circular of the 16th instant, I beg to say that this establishment does not make any steel.

It seems to me, however, that we have plants in this country capable of producing steel of any desired grade or quantity, and if none of them now have the requisite machinery to make heavy ordnance, some of them would undoubtedly put it in if they had a sufficient order to warrant the expenditure.

If this be not so I entirely misjudge the enterprise and spirit of my countrymen.

I have the honor to be, very respectfully,

M. CHURCHILL,
President.

To the Select Committee, &c.

OTIS IRON AND STEEL COMPANY.

STATEMENT OF MR. CHARLES A. OTIS.

CLEVELAND, OHIO, *February* 9, 1885.

The CHAIRMAN. Please state your name and present position.

Mr. OTIS. Charles A. Otis, president of the Otis Iron and Steel Company, Cleveland, Ohio.

The CHAIRMAN. Please give your age and your practical experience in the subjects this committee is investigating.

Mr. OTIS. I am fifty-seven years of age, and have been engaged in the manufacture of iron and steel since 1852.

The CHAIRMAN. Have you at any time been requested by the Government to supply steel for shafts, engines, boilers, ship and armor plates, and guns?

Mr. OTIS. Yes; we submitted proposals for ship, boiler, and armor plates.

The CHAIRMAN. Why did you not contract to furnish same?

Mr. OTIS. Because our price was too high.

The CHAIRMAN. What is the capacity of your works to manufacture steel for shafts, boiler-plate, ship-plate, armor-plate, and guns?

Mr. OTIS. Have a yearly capacity of 40,000 tons of open-hearth steel, and 60,000 tons of Bessemer steel.

The CHAIRMAN. What are the dimensions of the largest steel, gun parts, cast ingots, forging, shaft, armor-plate, ship-plate, and boiler-plate you have made, and in what state were they delivered?

Mr. OTIS. Have made 3-ton forgings, and plate up to 3 tons' weight and 110 inches wide; also plates 56 inches wide and 52 feet long, but cannot roll plates over 2 inches thick.

The CHAIRMAN. By what processes do you manufacture steel?

Mr. OTIS. Open-hearth and Bessemer.

The CHAIRMAN. Are you enlarging your plant, and if so, to produce what?

Mr. OTIS. No, sir.

The CHAIRMAN. What ores do you use?

Mr. OTIS. We do not use the ore, but manufacture the steel from pig-iron and wrought-iron blooms, which are mostly made from Lake Superior and Champlain ores.

The CHAIRMAN. Is there a marked difference in the various parts of the United States in the price of the pig and blooms?

Mr. OTIS. No very marked difference at present.

The CHAIRMAN. What experience have you had in the use of steam hammers and hydraulic casting and forging presses?

Mr. OTIS. None with hydraulic presses, but I have had an experience of 33 years with steam hammers, up to and including 12-ton tup.

The CHAIRMAN. What do you consider the comparative advantages and disadvantages of the two systems of forging—steam-hammer and hydraulic press—and your reasons for same?

Mr. OTIS. The steam-hammer for small work and the hydraulic press for large work would be best and cheapest in cost of plant.

The CHAIRMAN. Have you any tools and implements for the manu

facture of guns, similar to those cited on pages 40 to 44 of the Gun Foundry Board's report; can you manufacture such tools and implements equal in power and speed and for the cost stated therein?

Mr. OTIS. We are not tool-makers, and possess no such tools and implements, with the exception of melting plant, both open-hearth and Bessemer.

The CHAIRMAN. What do you consider the best method of supplying the Government with guns, armor, and war vessels?

Mr. OTIS. We think the steel should be procured from private individuals, and that the Government should fabricate the guns; and that at least one-half of the vessels should be built in the navy-yards.

The CHAIRMAN. Which do you consider the best locations for such a method of production?

Mr. OTIS. We think the sites selected by Gun Foundry Board are the most advantageous for the fabrication of guns.

The CHAIRMAN. Is there material in this country out of which the best gun steel can be made?

Mr. OTIS. Yes; without question.

The CHAIRMAN. Why, then, should not home manufacturers be limited to the use of native material?

Mr. OTIS. While we have all the material necessary in our country, we do not think it would be wise or economical to the Government to place any restriction as to where material should be obtained.

The CHAIRMAN. Why do steel manufacturers import foreign material?

Mr. OTIS. In substance, for economic reasons.

OTIS IRON AND STEEL COMPANY.

STATEMENT OF MR. S. T. WELLMAN.

CLEVELAND, OHIO, *February* 9, 1885.

The CHAIRMAN. Please state your name and present position.

Mr. WELLMAN. Samuel T. Wellman, superintendent Otis Iron and Steel Company, Cleveland, Ohio.

The CHAIRMAN. Of what scientific associations are you a member?

Mr. WELLMAN. The American Society of Mechanical Engineers, the American Institute of Mining Engineers, the Cleveland Society of Civil Engineers, the British Iron and Steel Institute, the German Society of Engineers, the German Iron and Steel Institute.

The CHAIRMAN. Pease give your age and your practical experience in connection with the subjects this committee is investigating.

Mr. WELLMAN. Age, forty-eight. Six years as assistant to superintendent of Nashua Iron and Steel Company; four years as engineer in the employ of the United States agents of Siemen's Furnace, and in the erection of said furnaces; twelve years in the erection and management of the Otis Iron and Steel Works.

The CHAIRMAN. In the manufacture of steel, to what chemical and mechanical tests do you subject it?

Mr. WELLMAN. To complete chemical analysis, and to all required mechanical tests of tensile strength, elastic limit, elongation, reduction of area, and cold bending.

The CHAIRMAN. What testing machine do you employ?

Mr. WELLMAN. The Olsen, manufactured by Tinius Olsen & Co., Philadelphia, Pa.

The CHAIRMAN. By whom are these tests made?

Mr. WELLMAN. By members of our establishment, in our own shops.

The CHAIRMAN. What experience have you had in the use of steam hammers and hydraulic casting and forging presses?

Mr. WELLMAN. I have had no practical experience with hydraulic casting and forging presses, but my experience with hammers, up to and including 12-ton tup, has extended over a period of eighteen years.

The CHAIRMAN. Have you ever compressed steel ingots in a liquid state, or seen the operation of such compression or hydraulic forging?

Mr. WELLMAN. No.

The CHAIRMAN. What do you know of liquid compression?

Mr. WELLMAN. I know that Sir Joseph Whitworth has obtained physical characteristics in steel that have otherwise been unobtainable.

The CHAIRMAN. What do you consider the comparative advantages and disadvantages of the two systems of forging—steam hammer and hydraulic press—and your reasons for same?

Mr. WELLMAN. The advantages of the hydraulic forging press, as it looks to me, are a more thorough and even working of the metal, and a more condensing effect, as the impact of the falling hammer is avoided; and a forging press of capacity to work a large-sized steel ingot would

undoubtedly be much cheaper in first cost and cost of running than a hammer to do the same work.

The CHAIRMAN. By what method can the Government best be supplied with guns, armor, and war vessels?

Mr. WELLMAN. I think that the steel and other materials should be procured from private firms, and the guns, armor, and vessels finished by the Government in its own shops and yards.

The CHAIRMAN. Which do you consider the best locations for such a method of production?

Mr. WELLMAN. I should think the locations mentioned by the Gun Foundry Board the best for the purpose.

The CHAIRMAN. Is there material in this country out of which the best gun steel can be made?

Mr. WELLMAN. Yes; there is no question about that.

The CHAIRMAN. Is there any reason why the steel manufacturers of the United States should not be restricted to the use of home material?

Mr. WELLMAN. I think not.

The CHAIRMAN. Why do steel manufacturers import foreign material?

Mr. WELLMAN. Only because it may be cheaper for the time being.

The CHAIRMAN. Can any works in the United States (with present plant) produce any grade of steel which would probably be called for by Government specifications, for guns and armor, equal, metallurgically, to foreign?

Mr. WELLMAN. Yes.

The CHAIRMAN. Under existing conditions, what will be the additional cost of such steel, as compared with the foreign of the same quality laid down in the United States, duty free?

Mr. WELLMAN. Probably at least 50 per cent. more.

The CHAIRMAN. By what process would you make and to what treatment would you subject the steel for modern heavy guns, heavy armor plates, and plate suitable for ships and boilers?

Mr. WELLMAN. The open-hearth process. To get the best possible result for guns, I would use liquid compression, hydraulic forging, and oil tempering. I would roll boiler and ship plates direct from the ingot.

The CHAIRMAN. Are there any forges in the United States capable of properly forging steel shafts for ships of more than 1,500 tons, and the parts of modern ordnance heavier than 6 inches in caliber?

Mr. WELLMAN. No, sir.

The CHAIRMAN. Are there any rolls in the United States of a capacity to roll armor-plate of more than 2 inches thickness?

Mr. WELLMAN. There are rolls heavy enough, but none of them have suitable heating furnaces, nor tables and other machinery strong enough to handle modern armor-plates.

The CHAIRMAN. Where is the boundary between steel and iron?

Mr. WELLMAN. My idea is that chemically there is no boundary line—but physically there is—as the steel-making process of whatever kind keeps the metal fluid after the bulk of the carbon and silicon have left it, and the slag, being lighter, rises to the surface, leaving the pure, clean metal; but in the iron-making processes, when the bulk of carbon and silicon leave the metal, there is not enough heat in the furnace to longer keep it liquid, and it assumes a pasty state; when it is "balled" up every grain is covered with a coating of "slag," which accounts for the so-called fiber of wrought iron. The process by which a metal is made, should determine whether it is steel or iron.

The CHAIRMAN. At what stages of the manufacture are the blow-holes (gas holes) formed?

Mr. WELLMAN. When it is in a semi-pasty state; just before complete solidification.

The CHAIRMAN. What is the action of steel called "flowing"?

Mr. WELLMAN. Changing its form or shape, as it is forced to do, when work of any kind is put upon it.

The CHAIRMAN. Could all the parts of a 100-ton steam hammer be manufactured in the United States?

Mr. WELLMAN. Yes; as there are shops in this country that can manufacture fully as large parts as are necessary for a 100-ton hammer.

The CHAIRMAN. How is steel tempered, and why is oil generally employed instead of other fluids?

Mr. WELLMAN. By heating and immersing in a bath of oil, which is used because it has a more toughening effect on the metal than other fluids.

The CHAIRMAN. Why is not petroleum used?

Mr. WELLMAN. I do not know how it would work.

The CHAIRMAN. In what way is the quality of steel improved by working and treatment; is the density increased?

Mr. WELLMAN. Yes; both the density and ductility are increased.

The CHAIRMAN. In what part of the United States are the most suitable ores to be found for the manufacture of gun and ship steel?

Mr. WELLMAN. In the Lake Superior and Lake Champlain districts.

The CHAIRMAN. Have we the material, plants, and experience required to produce in quality, dimensions, and quantity steel suitable for the construction of modern armored vessels and the fabrication of modern heavy ordnance?

Mr. WELLMAN. We have the raw material, but not the plants or experience necessary.

The CHAIRMAN. What testing-machine do you consider the most suitable for the work required in the production of suitable steel for war vessels and heavy ordnance, and your reasons for the same?

Mr. WELLMAN. I consider the Olsen machine for all practical purposes as good as any made, because it is simple, get-at-able, and accurate.

The CHAIRMAN. In the production of such steel, with equal care of manufacture, can as good results be obtained by "washing," &c., medium or poor ores as with the best selected materials?

Mr. WELLMAN. I think not, as regards perfect uniformity.

The CHAIRMAN. Do you consider the presence of natural gas an advantage to the manufacturer of steel?

Mr. WELLMAN. It has a certain advantage as regards economy of fuel, but that bears a very small proportion to the total cost of high-class steel.

The CHAIRMAN. What is your opinion as to its comparative reliability, sufficiency, safety, and purity with other fuels?

Mr. WELLMAN. It has not as yet been enough used to fully determine these points.

The CHAIRMAN. Is it present in large supply in the vicinity of your works?

Mr. WELLMAN. It has not yet been discovered in our vicinity in any large quantity.

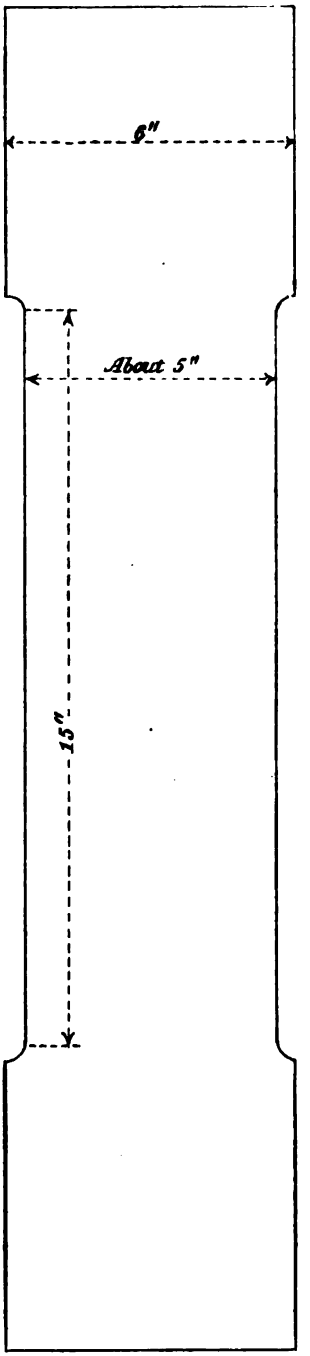
The CHAIRMAN. Please give a record of tests of your steel.

Mr. WELLMAN. The following table contains tests of steel for boiler-plate.

Testing machine record, Otis Iron and Steel Company.

[Memoranda of tests of Otis steel for the Calumet and Hecla Mining Company, E. D. Leavitt, jr., consulting engineer. Tests made on the Otis Iron and Steel Company's Olsen testing machine, in the presence of Mr. F. W. Dean, inspector for Mr. Leavitt, Cleveland, Ohio, December, 1884.]

Marks.	Description.	Dimensions.	Area section.	Area of least section after breaking.	Original length of minimum section measured between shoulders.	Length after breaking.	Least strain which produced a permanent set.	Breaking strain.	Elastic limit per square inch.	Tensile strength per square inch of original minimum cross-section.	Reduction of cross-section by breaking.	Ultimate elongation in 15″.
			″	″	″	″	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*P. ct.*	*P. ct.*
1	$\frac{5}{16}$″ steel plate	4.931 × .560	2.761	1.287	15	19.18	100,000	152,150	36,220	55,100	54	27.9
2	do	4.917 × .550	2.704	1.560	15	18.38	109,000	152,960	40,310	56,570	42	22.5
3	do	4.948 × .576	2.850	1.660	15	18.86	112,000	164,540	39,300	57,730	42	25.7
4	do	4.963 × .568	2.819	1.390	15	19.39	105,000	156,000	37,250	55,340	51	29.3
5	do	4.946 × .568	2.809	1.619	15	18.88	98,000	161,420	34,890	57,470	43	25.9
6	do	5.037 × .568	2.861	1.520	15	18.90	103,000	157,010	36,000	54,880	47	26.0
7	do	4.978 × .554	2.758	1.715	15	18.50	107,000	154,420	38,800	55,990	38	23.3
8	do	4.969 × .555	2.758	1.628	15	18.45	107,000	153,350	38,790	55,600	41	23.0
9	do	5.028 × .553	2.780	1.640	15	19.00	107,000	161,250	38,490	58,000	41	25.3
10	do	4.968 × .572	2.842	1.548	15	18.84	107,000	152,300	37,650	53,590	46	25.6
11	do	4.964 × .565	2.805	1.609	15	18.38	112,000	162,530	40,000	57,940	40	22.5
12	do	4.955 × .554	2.745	1.539	15	18.45	108,000	158,150	39,340	57,610	44	23.0
13	do	4.889 × .564	2.757	1.584	15	18.76	105,000	154,000	38,080	55,860	43	25.1
14	do	4.994 × .592	2.956	1.801	15	18.77	112,000	176,950	37,890	59,860	39	25.1
15+16T	$\frac{3}{8}$″ steel plate	4.969 × .388	1.928	1.000	15	18.40	80,000	114,600	41,490	59,440	48	22.7
15+16B	do	4.958 × .387	1.889	1.058	15	17.95	82,000	110,000	43,410	58,230	44	20.0
17	do	4.969 × .383	1.903	.956	15	19.00	78,000	108,500	40,990	57,020	50	26.7
18	do	4.977 × .385	1.916	1.096	15	19.06	77,000	108,000	40,180	56,360	42	27.0
19	do	4.965 × .381	1.892	1.955	15	18.58	78,000	105,920	41,230	55,980	50	23.9
20	do	4.836 × .395	1.910	.989	15	18.70	77,000	110,330	40,310	57,750	48	24.7
21	do	4.946 × .385	1.904	.968	15	18.98	75,000	107,100	39,390	56,250	49	26.5
22	do	4.904 × .385	1.888	.874	15	19.26	72,000	105,100	38,140	55,660	54	28.4
23+24T	do	4.968 × .389	1.933	.948	15	18.91	78,000	108,600	40,350	56,180	51	26.1
23+24B	do	4.947 × .392	1.939	1.053	15	18.72	81,000	117,500	41,770	60,600	46	24.8
25+27T	do	4.972 × .394	1.959	.982	15	18.55	74,000	116,960	37,770	59,700	50	23.7
25+27B	do	4.991 × .380	1.897	.880	15	19.57	71,000	106,480	37,430	56,130	54	30.5
28+30T	do	4.930 × .377	1.859	.912	15	18.54	75,000	109,100	40,340	58,680	51	23.6
28+30B	do	4.896 × .395	1.934	1.028	15	18.82	74,000	109,450	38,260	56,590	47	25.5
31	$\frac{7}{16}$″ steel plate	4.931 × .430	2.120	1.154	15	18.82	83,000	126,660	39,150	59,750	46	25.5
32+69T	$\frac{1}{2}$″ steel plate	4.966 × .503	2.498	1.417	15	18.36	95,000	134,300	38,030	53,760	44	22.4
32+69B	do	4.964 × .495	2.457	1.397	15	17.83	107,000	146,280	43,550	59,540	43	18.9
33	do	4.961 × .502	2.490	1.389	15	18.71	95,000	132,730	38,150	53,310	44	24.7
34	$\frac{3}{4}$″ steel plate	4.009 × .740	2.967	1.837	15	18.86	105,000	169,330	35,390	57,070	38	25.7
35+40	$\frac{5}{16}$″ steel plate	4.971 × .553	2.749	1.486	15	18.94	108,000	146,070	39,290	53,140	46	26.3
41+46	do	4.443 × .560	2.488	1.546	15	18.50	95,000	139,500	38,180	56,070	38	23.3
41+47	do	5.003 × .559	2.797	1.463	15	19.34	98,000	150,990	35,040	54,000	48	29.0
48+51T	do	4.908 × .558	2.739	1.387	15	19.28	104,000	147,310	37,970	53,780	49	28.5
48+51B	do	4.934 × .560	2.763	1.640	15	18.38	112,000	161,820	40,540	58,570	41	22.5
52+55T	$\frac{3}{8}$″ steel plate	4.976 × .380	1.891	.960	15	18.68	77,000	106,490	40,720	56,310	49	24.5
52+55B	do	4.970 × .385	1.913	.975	15	18.36	79,000	115,380	41,290	60,310	49	24.0
56+62T	do	4.919 × .392	1.928	.948	15	18.53	82,000	115,360	42,530	59,830	51	23.5
56+62B	do	4.913 × .386	1.896	1.014	15	18.72	76,000	105,820	40,080	55,920	47	24.8
63+68T	do	4.899 × .394	1.930	.962	15	18.86	76,000	114,850	38,850	59,510	50	25.7
63+68B	do	4.921 × .395	1.944	.921	15	18.68	73,000	109,000	37,560	56,070	53	24.5
Average of forty-four tests									39,100	56,888	46	24.9



Shape and Size of Specimens.

LETTER FROM THE PACIFIC ROLLING MILL COMPANY.

SAN FRANCISCO, *October* 16, 1884.

GENTLEMEN: We have the honor to report that this company, besides its rolling mills, forges, and machine shops, has in operation a Siemens-Martin steel plant, with all the most modern appliances and improvements, capable of producing a 20-ton ingot, and with the success and experience we already have, we are perfectly certain of being able to produce a quality of steel that will prove inferior to none.

The plant was originally laid out to admit of its extension to meet any of the requirements of the future. We have all of the patterns for the cranes, producers, &c., and could erect six or eight additional furnaces in nearly the same time as one. It would require a greater period to get in place the large hydraulic presses for forging and liquid compression.

This company will be glad to co-operate with the Government in the manufacture of steel for heavy ordnance and armor-plate, and are ready to erect the necessary plant.

As the Government will be the only customer, it would be proper that a guarantee should be given that sufficient work would be required to keep the plant in operation.

It would require two and a half years to get such a plant in good working order.

As far as raw material is concerned this State has an abundance of iron ore that has no superior for purity and adaptability for making the finest steel. I will forward a list of analyses of some of these deposits in different parts of the State. The samples are taken from large lots of the ore, are a fair average, and can be depended upon. Most of the deposits are situated on well-timbered land, and there is no reason why charcoal iron equal to the best Swedish brands cannot be manufactured from them. The only desideratum is a sufficient demand for such a high-grade metal.

Reiterating the willingness of this company to prepare for the manufacture of Government ordnance and armor-plate, and their ability to do so,

We remain, sir, very respectfully yours,

THE PACIFIC ROLLING MILL COMPANY,
By P. NOBLE,
Superintendent.

To the Select Committee, &c.

Analyses of California ores.

Constituents.	Limonite from San Luis Obispo County.[1]	Magnetite on line of Central Pacific Railroad, near Pilot Hill, 12 miles from Auburn.[2]	Red hematite, Napa County, 3 miles from railroad.[3]	Brown hematite, about 15 miles from railroad, Berryessa Valley.[4]	Brown Hematite immediately on line of San Joaquin and Sierra Nevada Railroad and about 50 miles from San Francisco.[5]	Magnetite at the junction of Pit and McCloud Rivers, about 18 miles from railroad.[6]
Silica	11.200	3.950	30.900	17.650	9.44	2.025
Iron, sesquioxide	63.591	.....	48.670	66.250	.....	.....
Iron, magnetic oxide	3.406	94.411	.....	.....	70.17	96.524
Manganese, oxide	.....	None.	.516	.229	.....	.....
Alumina	1.565	1.041	9.156	1.464	10.60	1.362
Lime	3.416	.588	3.514	11.375	.....	.597
Magnesia	.472	.255	.315	.828	.....	.242
Copper, oxide	.225	.....	.....	.....	.....	.....
Sulphuric acid	.089	Trace.	.049	039	.08	Trace.
Phosphoric acid	4.149	.067	3.399	.486	2.22	.069
Water	.....	.....	.....	2.550	.....	.....
Water and organic matter	11.400	.....	2.575	.....	.....	.....
Moisture	.....	.....	.....	.....	6.88	.....
Total	99.533	100.312	99.094	100.671	99.34	100.810
Metallic iron	44.514	68.367	34.055	46.375	49.12	69.397
Sulphur	.035	None.	.019	.015	.012	Trace.
Phosphorus	1.839	.029	1.484	.212	.97	.026

[1] This ore is worthless.
[2] A high grade of ore and suitable for making the finest steel.
[3] Worthless.
[4] Of no value.
[5] Of no value for steel.
[6] Very fine.

Constituents.	Magnetic ore in Sierra County.[1]	Magnetic ore in Shasta County, near railroad.[2]	Magnetite near Oroville.[3]	Magnetite from Clipper Gap, and now being used by the blast furnace of the California Iron Company, at Hotaling.[4]	Magnetic ore 7 miles from Folsom.[5]	Brown hematite 15 miles from San Francisco.
Silica	.....	.....	.....	2.49	.....	11.490
Alumina, moisture, &c	.....	.....	.....	.....	1.738	32.005
Iron oxide	91.21	94.440	61.43	85.21	94.640	55.970
Sulphuric acid	.10	.198	.020	Trace.	.....	.400
Phosphoric acid	.042	.029	.054	.61	.032	.135
Moisture	.....	.706	.....	.....	.....	.....
Insoluble matter (chiefly silica)	.....	1.340	21.58	.....	.....	.....
Silica, alumina, &c	8.32	.....	.....	.....	.....	.....
Undetermined matter (chiefly alumina and lime)	.....	.....	16.916	11.69	.....	.....
Soluble alumina, &c	.....	3.287	.....	.....	.....	.....
Silica and insoluble matter	.....	.....	.....	.....	3.590	.....
Total	99.572	100.000	100.000	100.000	100.000	100.000
Metallic iron	62.63	66.11	43.00	59.25	66.250	39.18
Sulphur	.04	.079	Trace.	.....	.....	.160
Phosphorus	.018	.013	.024	.27	.014	.058

[1] Very fine.
[2] Suitable for fine steel.
[3] Not suitable for steel making.
[4] Good iron, but too high in phosphorus for steel.
[5] Extremely pure and rich, and easily reduced.

LETTER FROM THE PENCOYD IRON WORKS.

PHILADELPHIA, *August* 11, 1884.

GENTLEMEN: Answering your circular letter of July 16, would say that we are prepared to furnish, in steel, all the various sections of which the hulls of vessels are composed, such as angles, deck-beams, channels, tees, &c., the quality of the same to conform to either the English Lloyds specifications or to those adopted by the United States in the cruisers now building.

Yours, respectfully,

A. H. ROBERTS & CO.

To the Select Committee, &c.

PENNSYLVANIA STEEL COMPANY.

STATEMENT OF MR. L. S. BENT.

STEELTON, PA., *November* 26, 1884.

The CHAIRMAN. Please state your name and present position.

Mr. BENT. L. S. Bent; vice-president and general manager of the Pennsylvania Steel Company; works located at Steelton, Pa.

The CHAIRMAN. Please state your age and your practical experience in connection with said subjects.

Mr. BENT. Am fifty-three years old. Have not had any practical experience in the making of guns or armor-plate, but have had many years' experience in the manufacture and treatment of steel.

The CHAIRMAN. Have you at any time been requested by any Government to supply steel shafts, engines, boilers, ship-plates, guns or armor, or steel for the same?

Mr. BENT. Have received circulars asking for propositions for armor-plate, and have received same from the Gun Foundry Board asking for approximate estimates for the construction of guns, but have never delivered any, having never engaged to do so.

The CHAIRMAN. What are the dimensions of the largest steel shafts you have manufactured?

Mr. BENT. Three shafts, 11 feet 8 inches long; diameter, 20, 14, and 17½ inches. One shaft, 11 feet 1½ inches long; diameter, 12, 16, and 20 inches. One shaft, 19 feet long; diameter, 7 inches. One shaft, 18 feet 5½ inches long; diameter, 7½ inches. One shaft, 18 feet 2 inches long; diameter, 7 inches. One shaft, 12 feet 5 inches long; diameter, 9, 8, and 7 inches.

The CHAIRMAN. By what process were they manufactured?

Mr. BENT. They were made from open-hearth steel; forged under a 14-ton hammer.

The CHAIRMAN. What is the capacity of the Pennsylvania Steel Company's Works?

Mr. BENT. We have one Bessemer plant containg two 6-ton converters, capable of producing 15,000 tons per month; one Bessemer plant containing three 8-ton converters, capable of producing 20,000 tons per month; and one open-hearth plant containing two 30-ton furnaces, capable of producing 4,000 tons per month; making a total producing capacity of 39,000 tons per month.

We have not, however, in either of our Bessemer plants, machinery capable of handling large masses of steel, as they were constructed with reference to the handling only of small ingots, not exceeding 8 tons in weight. Our open-hearth plant, which is of very recent construction, would handle large masses of steel; and for a further explanation of our facilities in this direction, I hand you a copy of a letter (page 352) written in reply to an inquiry of Captain Michaelis, U. S. Army, touching the subject of heavy ordnance, which fully sets forth our position. In regard to the production of armor-plate the same difficulty arises that is referred to in said letter; that is, the lack of competent machinery to handle the steel after casting.

In looking over the estimated cost of constructing plants for producing and handling large masses of steel, it strikes me that they will fall far

short of the actual cost in this country. I venture to give this opinion from experience in this matter.

The ore resources of this company are beyond question as to quantity and quality.

It would give me very great pleasure to have your committee visit these works, where every effort in our power will be made to impart such information as may be useful to you in your investigations.

The CHAIRMAN. Are you enlarging your plant?

Mr. BENT. We are not.

The CHAIRMAN. In the manufacture of steel, to what chemical and mechanical tests do you subject it?

Mr. BENT. We make complete chemical analyses in our own laboratory. We make also such physical tests as working at different degrees of heat, and also working cold; and we make use of testing-machine.

The CHAIRMAN. What testing-machine do you employ?

Mr. BENT. We have on hand at this time a Riehlé and a Thurston machine, and are now negotiating for one of more modern construction.

The CHAIRMAN. By whom are these tests made?

Mr. BENT. By our assistant superintendent.

The CHAIRMAN. What ores do you use, and where do you get them?

Mr. BENT. We use chiefly foreign ores, and obtain them mostly from Spanish ports.

The CHAIRMAN. Name the mines you own.

Mr. BENT. We have large interests in Spanish mines.

The CHAIRMAN. What experience have you had in the use of steam hammers and hydraulic casting and forging presses?

Mr. BENT. We have had continuous experience with steam hammers for the past ten years. Have not had any experience with hydraulic forging-presses.

The CHAIRMAN. Have you ever compressed steel ingots in a liquid state, or have you seen the operation of such compression, or of hydralic forging.

Mr. BENT. We have not.

The CHAIRMAN. What do you know of liquid compression?

Mr. BENT. Nothing more than could be gained from publications on the subject.

The CHAIRMAN. Have you ever manufactured hydraulic casting or forging presses?

Mr. BENT. We have not.

The CHAIRMAN. What do you consider the comparative advantages and disadvantages of the two systems of forging (steam-hammer and hydraulic press), and what are the reasons for your opinion?

Mr. BENT. Have formed a favorable opinion as to the advantages of the hydraulic press over the steam-hammer for reducing steel, from information gained from the members of the Gun-Foundry Board, and from their report upon this subject.

The CHAIRMAN. Have you any tools and implements for the manufacture of guns similar to those mentioned in the report of the Gun-Foundry Board pages 40 to 44? Can you manufacture such tools, equal in power and feed, at the cost estimated therein? How much time would you require in which to finish them?

Mr. BENT. We have furnaces and appliances for making such steel, and hammers for reducing the same into shape, as well as tools for boring and rough-turning the same. We could not produce the necessary tools for large guns with the same facility or as quickly as plants in this

country that make heavy tools a specialty. Such tools, in my opinion, could be produced in this country as soon as the steel plant could be made ready.

The CHAIRMAN. By what method can the Government best be supplied with guns, armor, and war vessels?

Mr. BENT. In my judgment, so far as guns and armor-plate are concerned, the plan recommended by the Gun-Foundry Board is most practicable in regard to both economy of cost and saving of time.

The CHAIRMAN. What is your opinion of the comparative cost of supply—wholly in Government works, partly in such works and partly by contract with private builders, or wholly in private works? In case of divided labors, how should the division be made?

Mr. BENT. By the Government taking advantage of the experience and appliances of steel plants now in operation there would result the saving of a large outlay by the Government and of much valuable time, which would be absorbed by works conducted wholly by the Government. The assembling and finishing of the guns, for the present, at least, would seem to fall naturally into the hands of the Government, and the division of labor as set forth in the report of the Gun-Foundry Board would seem to be the very best to be attained in the present state of the art. Armor-plate should be finished at the plant where it is made.

The CHAIRMAN. Which do you consider the best location for such a method of production?

Mr. BENT. That which is most easy of access, made so by two or more prominent railroad connections, and which is midway between the Government finishing shops and tide-water. The location should be somewhat isolated, and not in the midst of a large and populous city.

The CHAIRMAN. Is there material in this country out of which the best steel can be made?

Mr. BENT. There is.

The CHAIRMAN. Is there any reason why the steel manufacturers of the United States should not be restricted to the use of home material?

Mr. BENT. Yes. By such restriction manufacturers would be compelled to use the product of a few mines situated on the western lakes, thereby, on account of a long line of transportation, increasing the cost of ore to the Eastern manufacturers.

The CHAIRMAN. Why do steel manufacturers import foreign material?

Mr. BENT. Strictly as a matter of economy.

The CHAIRMAN. Can any work in the United States (with present plant) produce any grade of steel that would probably be called for by Government specifications for guns and armor equal, metallurgically, to foreign?

Mr. BENT. If they have an open-hearth plant, yes; otherwise, no.

The CHAIRMAN. Under existing conditions, what will be the additional cost of such steel, as compared with the foreign of the same quality, laid down in the United States, duty free?

Mr. BENT. Under existing conditions, and taking steel rails as our standard, the cost would not be very much greater.

The CHAIRMAN. By what process would you make, and to what treatment would you subject steel for modern heavy guns, armor-plate, and plate for boilers and ships?

Mr. BENT. Would use the open-hearth process; and would follow the treatment which has given the best results in foreign countries, until such time as our own experience suggested improvements.

The CHAIRMAN. Are there any forges in the United States capable of properly forging steel shafts for ships of more than 1,500 tons, and the parts of modern ordnance heavier than six inches caliber?

Mr. BENT. There are none within my knowledge.

The CHAIRMAN. Are there any rolls in the United States of sufficient capacity to roll armor-plate of more than two inches in thickness?

Mr. BENT. There are none within my knowledge.

The CHAIRMAN. Where is the boundary between iron and steel?

Mr. BENT. That is still an open question. Chemically, there is not, in my judgment, any difference.

The CHAIRMAN. At what stages of the manufacture are the blow-holes—gas holes—formed?

Mr. BENT. In open-hearth practice, at the moment of solidification.

The CHAIRMAN. What is the action of the metal called "flowing?"

Mr. BENT. As we use the term it is the movement of the particles of the metal over each other, under the influence of force applied by rolls, hammer, or press.

The CHAIRMAN. Could all the parts of a 100-ton steam hammer be manufactured in the United States?

Mr. BENT. Yes.

The CHAIRMAN. How is steel tempered; and why is oil generally used instead of other fluids?

Mr. BENT. By being heated to a uniform heat, and then plunged into a bath of cold liquid. Oil is preferred because it has the virtue of transmitting and retaining uniform heat; and it does not chill the steel so rapidly as to cause cracks in the surface.

The CHAIRMAN. Why is not petroleum used?

Mr. BENT. There would be danger of explosion from generated gas.

The CHAIRMAN. In what way is the quality of steel improved by working and treatment? Is the density increased?

Mr. BENT. It makes it more homogeneous by reducing the size of the crystals; and it increases its density, tensile strength, and ductility.

The CHAIRMAN. In what part of the United States are the most suitable ores to be found for the manufacture of gun and ship steel?

Mr. BENT. In the Lake Superior district.

The CHAIRMAN. Have we the material, plants, and experience required to produce in quality, dimensions, and quantity steel suitable for the construction of modern armored vessels, and for the fabrication of modern heavy ordnance?

Mr. BENT. We have not.

The CHAIRMAN. What testing-machine do you consider most suitable for the work required in the production of steel suitable for war vessels and heavy ordnance? Give the reasons for your preference.

Mr. BENT. The experience of makers of these machines for heavy work has been limited; and no uniform standard has been adopted by which the various makers' work can be proved as to accuracy. Without such a standard, and with limited experience, I have no preference.

The CHAIRMAN. In the production of such steel, with equal care of manufacture, can as good results be obtained by the "washing," &c., of medium and poor ores, as with the best selected material?

Mr. BENT. My preference would be for the best material to start with, as there is more or less uncertainty as to results obtained by the various processes of washing poor ores. At the best it is entirely a matter of economy.

The CHAIRMAN. Do you consider the presence or the proximity of natural gas an advantage to the steel manufacturer?

Mr. BENT. Experience only can solve this question. The only advantage would be that of economy.

The CHAIRMAN. What is your opinion of its reliability, sufficiency, safety, cost, and purity, as compared to other fuels?

Mr. BENT. I should require a more extended experience than I now have to enable me to answer this question intelligently.

The CHAIRMAN. Is it found in large supply in the vicinity of your works?

Mr. BENT. It is not.

The CHAIRMAN. Please give a record of tests of your steel.

Mr. BENT. The following are tests of structural steel made by the open-hearth process within the last month.

Diameter of piece.	Elastic limit.	Breaking strain.	Elongation in 8 inches.	Reduction of area.
"	*Lbs.*	*Lbs.*	*P. ct.*	*P. ct.*
.775	54,000	83,686	21.1	34.96
.775	52,966	82,627	23.44	32.53
.775	59,110	83,627	23.05	37.06
.775	59,110	81,568	23.27	38.35
.764	53,447	77,442	.....	42.76
.758	50,964	75,338	19.14	38.59
.759	53,179	81,986	19.53	44.07
.765	52,088	85,079	21.88	39.59

LETTER FROM L. S. BENT TO CAPT. C. E. MICHAELIS.

STEELTON, PA., *July* 28, 1884.

Capt. C. E. MICHAELIS,
Frankford Arsenal, Philadelphia:

MY DEAR SIR: Your esteemed favor of the 29th of April has come to hand, and I will endeavor to answer your inquiries in a general way, making such suggestions as may occur to me. Not having given the matter much serious thought I fear that I shall not be able to render you much aid beyond placing before you the facts which follow.

Our open-hearth furnaces, of which there are two (each having a nominal capacity of 30 tons), can melt without alteration from 37 to 40 tons each, thus enabling us to make a casting of from 75 to 80 tons (including sink-heads, sprues, &c.). At present, however, we are not able to handle with our cranes an ingot requiring a hoisting force of more than 20 tons. Our pits (7 feet wide) are only 11 feet deep. They were made of this depth in order to enable us to cast large ingots for our large hammer. These pits might be deepened to 20 feet without great trouble or expense, judging from the character of the soil at the present depth. This would permit the casting of guns of small caliber, requiring a length of casting, including riser-head, of not more than 20 feet 6 inches, and a weight of not more than 20 tons. For larger castings a special pit and more powerful cranes would be necessary. Such a special pit, 20 feet in diameter or less, could be sunk in front of the furnaces, on a line running midway between them. Two cranes (either hydraulic or steam) of a capacity of 120 tons each, would have to be erected on opposite sides of this pit.

As the bottom of the roof cord in our open hearth plant is only 33 feet above the general level, a question arises as to whether or not this

height is sufficient to allow the handling of the largest guns mentioned in your letter. If it is not, the roof will have to be raised to the height required to put in two 120 ton traveling cranes, running on a track supported on columns. This would involve the removal of our present hydraulic cranes, and the substitution in their stead of two 10-ton traveling cranes, supported on the same posts or columns at a lower level. This would make the whole floor space available both for the casting of ordinary ingots and for the casting of guns.

The changes necessary for casting would be slight, and consequently inexpensive. It is very difficult to estimate the cost of other changes. The pits with jib-cranes would cost probably not less than $10,000; and the pit, with traveling cranes, not more than $150,000. Heavy trucks for transportation would have to be provided, either by the company or by the Government. It is very difficult to make an estimate of the time that would be required to make these changes. Probably not less than eighteen months would be required, from the time when the plans were completed. The cost per pound of such work, I could not estimate with my present limited knowledge as to what would be required by the Government in the way of a guarantee. In the event of failure would the loss fall on the contractor?

In making the required changes we would be deprived of the use of our plant for quite a long time, and be obliged to give up a portion of our present business. What inducement would the Government offer us for giving up a profitable working plant or changing it into an experimental one? In my judgment, until such time as the Government is willing to secure the contractor against possible loss, responsible parties will not come forward and place their works and their capital at its service.

I think that we possess greater facilities for such work than most other establishments, and that we would need to make fewer alterations and additions to our plant to enable us to turn out large guns than any other firm or corporation in this country. From our experience with smaller work I am led to believe that larger castings for guns could be made with the regularity and with the solidity and strength required. Of course, some time might be required to fully develop such a new feature in our business, to overcome the difficulties and risks attending the casting and handling of such large masses of steel, and to fulfill all the conditions required. In conclusion, I will say that I have no doubt that the Pennsylvania Steel Company would enter into any equitable arrangement with the Government whereby the desired results could be obtained. I would most certainly do all in my power to forward any and all experiments that the Department would undertake.

Yours, truly,

L. S. BENT,
Superintendent.

Analysis of Pennsylvania Steel Company's ore.

	Per cent.
Iron in the natural state	63.78
Iron dried at 212 degrees	64.11
Moisture	.51
Specific gravity	4.78
Phosphorus	.0968

STATEMENT OF MR. T. J. PETER.

BRIERFIELD, ALA., *November* 11, 1884.

To the Select Committee of the United States Senate on Ordnance and War Ships:

GENTLEMEN: We are progressing very satisfactorily now with our works at Brierfield. We are making about 500 kegs of nails per day. We have fifty coke-ovens in operation, and within thirty days will have our machinery for crushing and washing the coal in operation. The following analysis of the coke we are now making was made by Emile Sjostahd, esq., the chemist of the Shelby Iron Works:

	Per cent.
Fixed carbon	92.39
Ash	6.91
Sulphur	0.32

We are not running our furnace, the "Bibb," but we are repairing it preparatory to blowing in. The following is a partial analysis of our iron, made by Regis Chauvenet & Brother, of Saint Louis:

	Per cent.
Silicon	1.89
Phosphorus	0.197
Manganese	0.494

This was the ordinary run of our furnace iron. By selecting our ore banks, we can unquestionably reduce the phosphorus below one-tenth of 1 per cent., and make an excellent Bessemer pig. As it is, this iron is an excellent article for the manufacture of steel by the open-hearth process.

The phosphorus could be washed out by the Krupp dephosphorizing process, or an excellent article of steel could be made of this iron just as it comes from our furnace without any ore selection, by the Clapp and Griffith process, now in successful operation at the works of Messrs. Oliver Bros. & Phillips, at Pittsburgh. I have a letter, dated October 25, 1884, from James P. Witherow, esq., an eminent metallurgical engineer residing in Pittsburgh, from which the following is an extract:

Yesterday we made in the Clapp and Griffith converter, special tests with phosphoric pig iron. The whole charge run into the converter contained one-half of 1 per cent. of phosphorus. Tests of the steel produced from this gave marvelous results, rods of it bending double, cold, without either flaw or fracture.

I desire to call your attention to the following extracts from an article published in volume 12, numbers 1 and 2, of the Southern Historical Society Papers, printed in January, 1884, at Richmond. The article was found among the papers of the late General Josiah Gorgas, chief of ordnance of the Confederate States.

Page 83:

The iron obtained from the brown hematite at the furnaces in Bibb County, Brierfield, and from the Shelby Works, was admirable, the former being of unusual strength.

Page 88:

To these would have been added a foundry for heavy guns at Selma or Brierfield, Ala., *at which latter place the strongest iron in the country was produced.*

In conclusion, permit me to say that it is the intention of the Brierfield Coal and Iron Company to erect, within a short time, a plant for making steel with converters, and also an open-hearth plant.

I remain, yours truly,

T. J. PETER,
President Brierfield Coal and Iron Company.

LETTER FROM THE PITTSBURGH STEEL-CASTING COMPANY.

PITTSBURGH, PA., *August*, 1884.

GENTLEMEN: Your circular, dated July 16th, to hand, and in reply would say that our business is the manufacture of steel castings, both crucible and refined Bessemer. During the last fourteen years we have made fully 99 per cent. of all the steel castings that have been made in this country. We regret that the limited time allowed us to answer this circular prevents our giving fuller estimates of the cost of preparation to make the various sized castings required for guns and plates. In our crucible department we have a capacity of 15 net tons of castings per day, or 4,500 tons per annum, and yet work to advantage in our present location. The largest crucible steel castings we have made weighed 7,000 pounds. With a further expenditure of, say, $50,000 we would be able to produce a 14,000-pound casting. We have no results at hand of full mechanical or chemical tests made outside of our works. None of our castings show a tensile strength of less than 65,000 pounds per square inch, and usually run from 75,000 to 100,000 pounds per square inch, with an elongation of 2 per cent. and upwards.

We would now call your attention to our refined Bessemer department, which has a capacity of 150 tons per day of castings and rolled slabs or blooms. The largest castings we have made in this department weighed 9 tons. With a further expenditure of $10,000, we could produce an 18-ton casting. We are now prepared to roll plates, provided the width is not over 3 or 4 feet, the thickness not over 9 inches, and the weight not over 3 tons, which is the capacity of our hydraulic heating-furnace cranes. With a further expenditure of $10,000 we would be able to roll a 6-ton plate. Our refined Bessemer castings and rolled steel have been thoroughly tested, both chemically and mechanically. In recent tests made of refined Bessemer-steel casting at the Washington navy-yard, the pieces being taken from some steel gun-carriage castings furnished, the results were as follows:

Marks.	Ultimate strength per square inch.	Elongation.	Elastic limit.
	Pounds.	*Per cent.*	*Pounds.*
A	88,000	17.6	43,120
B	89,535	15.8	46,162

We have recently made for the Ordnance Department of the United States Navy five sets of 6-inch and four sets of 8-inch gun carriages; and have an order, yet unfilled, for fifteen sets of 6-inch gun carriages. Our experience with steam hammers is limited to small ones, but we are now putting in a 5-ton hammer. Though we have had no experience with forging-presses, we are in favor of them, and believe they will give the most satisfactory results.

We have tried compressing the liquid metal in the molds, but only in small castings, and found it was impracticable; but we believe in the

results of the process when applied to certain shapes of large castings. Should you find there is any further information you wish, that we would be able to give, we would be pleased to furnish it, as we believe it is to the best interests of the country that this work should be done, under Government inspection, by private corporations or individuals who have had practical experience, rather than by the Government.

Again regretting that the limited time prevents our putting further details at your disposal, we remain,

Yours, truly,

F. N. HOFFSTOT,
Secretary.

To the Select Committee, &c.

STATEMENT OF MR. JOHN IRWIN, JR.

PITTSBURGH, PA., *December* 8, 1884.

GENTLEMEN: According to promise we inclose you a copy of tests of our steel castings.

Mr. Hainsworth desires also to call your attention to the capabilities of our plant for producing steel ingots for ordnance.

We have a building 32 feet 4 inches square, built stronger than any other in the country; it was erected in this manner, with the view of increasing at any time the lifting capacity should we have a call to do so, the height enabling us to handle a long ingot.

At present we could with but slight expenditure handle an ingot of 25 tons in weight.

In regard to the tests inclosed we would say that we can find no record of better or more uniform results either at home or abroad, and we think that in a short time the superiority of refined Bessemer steel over that of any other method of manufacture will be universally acknowledged. In support of this assertion I would say that the Government requires in boiler-plate rivets and ship plates an elongation of 23 per cent., while in steel castings they are now asking a minimum elongation of 25 per cent.

Yours truly,

JOHN IRWIN, JR.,
Treasurer Pittsburgh Steel Casting Co.

To the Select Committee, &c.

Tests taken from castings of refined Bessemer steel not worked or forged.

[6-inch gun-carriage brackets.]

	Tensile strength.	Elastic limit.	Elongation.
	Pounds.	*Pounds.*	*Per cent.*
No. 1	89,000	43,000	17.6
No. 2	88,000	42,000	15.8
No. 3	85,700	32,800	13.08
No. 4	81,400	31,800	14.7
No. 5	79,000	32,400	17.5
No. 6	80,800	41,000	17.1
No. 7	76,400	39,200	15.25
No. 8	75,600	38,400	19.6
No. 9	63,300	31,000	17.5
(The above tests were from castings to meet requirements of 60,000 tensile and 5 per cent. elongation.)			
Test at Washington navy-yard	71,000	35,000	27.1
Same at Pittsburgh testing laboratory	64,200	47,800	31
Steel cut from casting and reduced by forging 22 per cent., cooled slowly	99,000	62,000	27
Worked as above and oil tempered	102,000	61,400	26
(This material, we think, would be about the right temper and strength for guns. Requirements of above steel 60,000 tensile and 25 per cent. elongation.)			
Test of oil-tempered crucible steel.			
Fly-wheel for Howell's torpedo*	120,000	60,000	.....
6-inch steel shells, all of crucible steel.			
No. 1	68,200	26,700	.....
No. 2	81,700	33,200	.....
No. 3	65,900	56,500	.....
No. 4, oil-tempered	112,000	71,000	.....

* Tests made at Washington navy-yard showed a tensile strength of 90,000 pounds and an elastic limit of 40,000 pounds. (Chairman.)

LETTER FROM THE POTTSTOWN IRON COMPANY.

PHILADELPHIA, PA., *August* 1, 1884.

GENTLEMEN: Replying to your circular of July 16, we would say that we manufacture boiler and ship plates at present of iron, which are very favorably known in the market, owing to their extra finish and trimming as well as superior quality, fulfilling in all respects the requirements for marine works. Having a heavy and strong train and long rolls we can turn out plates wider than most other mills, and, in addition, have machinery at our rolls to handle the plates. Our capacity on favorable sizes would reach over 15,000 tons per annum, and were there sufficient encouragement the company could increase this, and possibly add a steel plant, as our mills are equally well adapted for this work. In view of the favorable position of our ores and coal in Pennsylvania, is there a better location for a shipyard or gun foundry than on the Delaware River, in or near Philadelphia, with its railroad connections to all parts of our vast territory?

Respectfully,

WILLIAM H. MORRIS,
Treasurer.

To the Select Committee, &c.

LETTER FROM THE STANDARD STEEL-CASTING COMPANY.

THURLOW, PA., *July* 29, 1884.

GENTLEMEN: In reply to your circular of the 16th instant, I would state that the Standard Steel-Casting Company has just commenced operations. We have one 10-ton Siemens-Martin furnace and one 18-pot Siemens crucible furnace. Our capacity is at present 3,000 tons of castings, but if we were to make ingots it could readily be increased to 18,000 tons per year. We *propose* to make soft-steel castings free from blow-holes, and the stock will be the same as that used in the manufacture of the best boiler and ship plates. The metal, as cast, will have a tensile strength of from 60,000 to 70,000 pounds per square inch, and an elongation of from 15 to 20 per cent. in an 8-inch section. It will contain about .20 per cent. carbon, .50 per cent. manganese, .30 per cent. silicon, and from .05 to .10 per cent. phosphorus.

I believe that metal of such physical and chemical characteristics would be admirably adapted for guns and ordnance. I would further call your attention to the fact established by Mr. Alex. Pourcell, of Terre Noire, France, and by the late Mr. Alex. Holley, that the density of this cast metal is greater than that of rolled or hammered steel. Of course guns made directly into shape would be very much less expensive than forgings, both as to first cost of plant and afterwards as to labor. The use of ferro-silicon has rendered it possible to make such castings practically solid.

Of course it is natural for us to believe that Chester and vicinity is admirably located for gun foundries and ship-yards. Bessemer iron, the basis for steel plate and castings, can be manufactured cheaper on the Delaware River from foreign ores than, perhaps, at any other point in the United States.

We believe it far preferable as regards both time and economy to have the work done by contract. There are a number of private concerns in this country who would be willing to undertake the work, providing there was some assurance of a steady market.

I wish to further call your attention to the remarkable metal made by Mr. Hadfield, of Sheffield. This "manganese steel" has a tensile strength of over 100,000 pounds per square inch, with the remarkable ductility of 20 per cent. in 8 inches.

I take the liberty of sending you marked copies of the Iron Age, containing my paper and discussion on steel, read at the Cincinnati meeting of mining engineers.

Any further information I can give you I shall be most happy to furnish at any time.

Yours, very respectfully,

PEDRO G. SALOM,
President.

To the Select Committee, &c.

TREDEGAR IRON COMPANY.

The following were sent to the committee by Gen. Joseph R. Anderson, president of the Tredegar Company:

Copy of letter from Joseph R. Anderson, president of the Tredegar Company, to Rear-Admiral Simpson, president of the Gun Foundry Board.

RICHMOND, VA., *June* 12, 1884.

SIR: I have had the honor to receive your letter of 15th ultimo, together with a copy of the report of the Gun Foundry Board. The subject has been carefully considered by this company, and I beg to give you our views. It is nearly fifty years since the construction of these works was begun, and they have been continuously operated since that time, $1,125,000 having been invested in the plant.

The works are located on James River, in the city of Richmond, and are connected, by rail, with all the railroads running from this city north, south, east, and west. There is probably no more salubrious and equable climate within the limits of the Union, and no location more accessible, both by rail and by water, to all points of our sea-coast, or safer from interference of the public enemy in time of war.

At the same time, we have convenient to us, in great abundance, iron ores and coals equal to the best in the country; ores best adapted to the fabrication of cannon and of steel being largely owned by this company.

In the year 1842 this foundry was adopted by the Army and Navy Departments as one of the foundries to make cannon for the two services, and the records of the Ordnance Department will show that, when proofs of the strength of iron used at the different foundries have been made, by firing to extremity guns of the same caliber made at each foundry, by the same schedule, the Tredegar gun has shown the greatest endurance of all.

We have thus had some education in the fabrication of iron ordnance. We have also had experience in iron ship-building, more especially in the construction of the machinery of some of the largest steam frigates in the Navy; as, for example, the Roanoke and Colorado, both of which were entirely fitted out at these works.

We would propose to enlarge our plant so as to enable us to cast and forge steel ingots up to 100 tons; also for rough boring and turning, and with suitable appliances for tempering. I am not now able to make an accurate estimate of the amount required to make such additions to our plant. I visited, last year, some establishments in Europe engaged in these operations, but not being then aware of the view your Board would take of the subject I did not obtain the information now wanted. But I judge, from the information contained in the report of the Board, that it would require about $560,000 to provide this establishment with machines, tools, and fixtures for such a steel plant as mentioned above. Leaving our present gun foundry, boring and turn-

ing mills (capable of turning out 10-inch guns) to stand as they are, and building the new works separately, I estimate approximately that this plant could be erected in about two years from its commencement, and I propose to undertake it, provided the Government will advance the money, under such guards as may be prescribed, to be reimbursed to the Treasury by reserving 5 per cent. upon all the ordnance work done for the Government.

I have the honor to be, your obedient servant,

JOSEPH R. ANDERSON,
President.

Rear-Admiral E. SIMPSON, *United States Navy,*
President Gun Foundry Board, Washington, D. C.

Copy of letter from Joseph R. Anderson, supplementary to the foregoing.

RICHMOND, VA., *June* 13, 1884.

SIR: Referring to my letter of 12th instant, I find that I omitted to state that the sum named as probably necessary to provide the proposed steel plant, does not include the cost of buildings. My proposition therefore is this:

If the Government will advance the amount necessary, this company will proceed at once to add the plant required for casting, forging, rough boring and turning, and tempering the parts of steel guns up to 100 tons. The reliable information given by the report of the Gun Foundry Board shows that the cost would be about $560,000, besides the cost of requisite buildings, which it is believed would be about $5,000 per square of 50 feet.

The money advanced to be secured by the Government retaining proprietorship of the plant until the whole amount has been reimbursed by a reservation of 5 per cent. of all bills for work done for the Government.

I will add, in response to the last paragraph of your letter of 15th May last, that the creation of the proposed plant for the manufacture of gun material will enable this company, with the aid of its present rolling-mill plant, to manufacture armor plate.

I have the honor to be, your obedient servant,

JOSEPH R. ANDERSON,
President.

Rear Admiral E. SIMPSON, UNITED STATES NAVY,
President Gun Foundry Board, Washington, D. C.

LETTER FROM THE UNION STEEL COMPANY.

CHICAGO, *July* 30, 1884.

GENTLEMEN: Your circular letter of the 16th has been referred to me in behalf of the Union Steel Company, and in reply have to say, that our works have a capacity for turning out 500 tons Bessemer steel per day, which is used chiefly for rails, plates, wire, and bar steel of various sizes. It is well adapted for frames of vessels and armor plates, but is not suitable for large castings. We have machinery for rolling thin plates, but nothing heavy enough for rolling armor plates.

Very respectfully yours,

A. B. STONE.

To the Select Committee, &c.

LETTER FROM THE IRON AND STEEL WORKS ASSOCIATION OF VIRGINIA.

GOSHEN BRIDGE, VA., *July* 26, 1884.

GENTLEMEN: Replying to your circular of the 16th instant I beg leave to say that at present we are not manufacturing steel. Our furnace capacity is 150 tons of neutral pig per diem. With basic plant, which we contemplate, I think we can produce 30,000 tons per annum of good chemical and physical steel. With steady market the capacity could be increased to any desired extent.

In my opinion the best location in America for ship-building, with attendant gun factories, &c., is upon the harbor of Hampton Roads or the James River, combining more facilities for strength in war and cheap material in peace than any other point upon the Atlantic coast. It is the nearest Atlantic port to California and the West; the most direct and accessible to the cheapest iron-producing States in the Union, and borders upon a vast area of magnetic and other steel ores, which are not excelled in quantity or quality by any deposits in this country, besides offering superior advantages for the importation of Cuban, Spanish, and other foreign steel ores, upon which our present steel supply is so greatly dependent; and the hard-wood forests of West Virginia, with its ten million acres of virgin timber, will supply the cheapest and best adapted woods. It needs but a full investigation of all the requisites to establish the strength of this point.

I beg leave to suggest that, as far as my experience goes, the Government could not rely upon any contract system for the satisfactory execution of such work as you propose further than the supply of material. The tools and existing appliances are so scattered and inefficient that they cannot be relied upon under the most favorable conditions. In my opinion, the Government should own and control an entire plant, upon the most favorably located deep water along the Atlantic coast.

I remain, your obedient servant,

WM. N. PAGE,
General Manager.

To the Select Committee, &c.

STATEMENT OF MESSRS. ALLEN & BLAISDELL.

SOUTH SAINT LOUIS, MO.,
February 10, 1885.

GENTLEMEN: Your favor of the 3d instant, making certain interrogatories in regard to our experience and plant for the construction of vessels of war, &c., is before us.

In reply we would state, that we were requested by the honorable Secretary of the Navy to submit proposals for the steel cruisers in July, 1883.

We submitted a proposal for the construction of the dispatch-boat Dolphin, having, at the request of the Secretary of the Navy, previously submitted the following statement of our facilities, receiving from him a reply that we were considered competent bidders.

We have never built at these works any vessels of war, the contract for the Dolphin having been awarded to Messrs. John Roach & Son, the lowest bidders, we being third, but we have built twenty-five iron and steel river steamers, many of them for the Government, such as snag-boats, dredge-boats, tow-boats, survey-boats, &c. We have been over ten years engaged in the business.

Our present equipment is about the same as stated in our letter to the Secretary of the Navy. We have about 500 feet of available river front, and are prepared to undertake the construction of any vessel which can be floated down the Mississippi River at flood stage, say of vessels whose extreme light draft would not exceed 15 feet without armament, stores, or fuel, which could be supplied at New Orleans. We can with our facilities employ profitably three hundred and fifty men, and could increase to double that number if necessary.

We have facilities for building boilers, tanks, &c., cupolas, retorts, chimneys, cranes, iron roofs, doors, plate and lattice columns and girders, short-span bridges, pier castings, wrought-iron work of all descriptions for blast furnaces, and are prepared to build steam boilers of any desired type or variety.

Our works are situated on the Mississippi River. The Atlantic and Pacific, and the Saint Louis, Iron Mountain and Southern Railways run by them, so that we have unequaled facilities for shipping to all points reached by water or railway. As our machinery and tools are of the latest and most improved construction, we are confident of being able to supply our manufactures at the lowest prices consistent with first-class work.

The steamboats which we have built have given the most perfect satisfaction, and from the experience gained in their construction, and the abundant facilities at our command, we are confident of our ability to supply vessels that will prove in every respect to possess all the advantages claimed for the iron hull.

The senior member of our company was in the service during the war as an engineer of the regular Navy, and was, for about two years, employed in the designing and general inspection of the monitors, where his opportunities for observing the work done on similar classes of ves-

sels, built in the navy-yards and by private parties, were very extended. It was and is his opinion that as good work can be had from private parties as is done in the navy-yards, and at greatly reduced cost. He believes also that in some cases private builders should submit plans and specifications in competition and under guarantees as to promised results. He also believes the Government should not, as has recently been the case, require guarantees of draft and speed from private builders, when they are required to rigidly follow the models, dimensions, and power specified by the Government. We believe the Government should rig and equip, as well as arm their vessels of war, and the rigging, spars, anchors, chains, &c., should be made at the navy-yards.

In dividing the work, engines and boilers might be built by one contractor and the hulls by another. This would produce wider competition, and probably lower prices. We, however, believe that it is best to award the whole contract to one party, permitting them to sublet either machinery or hulls to parties approved of by the Government. All work, of course, to be done under Government inspection.

We believe private competition will result in the construction of vessels at less cost, and lead to the use of improved machinery, and more skillful labor. Indeed, competent skilled labor is rarely found in our navy-yards.

Our opinion is that as far as can be done the Government should encourage the establishment and development of ship yards in new localities. As it is now, nearly all the ship-yards prepared to build first-class men-of-war are situated on the banks of the Delaware River, and the occupation of that river by an enemy would practically end our ability to construct naval vessels, while the blockade of its mouth would prevent our sending new vessels to sea.

Rolling-mills capable of furnishing materials already exist in different parts of the country, both East and West, and more would be built should the demand for them spring up.

Very respectfully, your obedient servants,

ALLEN & BLAISDELL.

To the Select Committee, &c.

SAINT LOUIS, MO., *June* 23, 1883.

SIR: In accordance with the requirements of the advertisement of the Navy Department, dated April 28, 1883, for the construction of four vessels for the United States Navy, we submit the following statement of our facilities for the construction of the dispatch boat called for by the advertisement. Our works have been in operation since December 1, 1874. Since that time we have built twenty-five vessels, of various types and sizes, with iron hulls. Many of these have been for the Government, such as snag-boats, dredge-boats, tow-boats, and survey-boats. We inclose letters from Col. W. E. Merrill, U. S. Army, and from Maj. Charles R. Suter, U. S. Army, the former in charge of the improvement of the Ohio River, and the latter in charge of snag-boats upon the Missouri and Mississippi Rivers, and of the improvement of the Missouri, and also a member of Mississippi River Commission. Letters from others for whom we have constructed vessels can be obtained if desired. We inclose a plan of our ground, showing its dimensions and location.

In our blacksmith-shop we have twelve fires, one steam hammer capable of forging up to 12 inches square or round, and one steam hammer

of one-half that capacity, with the necessary furnaces, &c.; also a plate and angle iron heating furnace, with bending flue, clamps, &c. In our boiler shop we have a 54-inch Bement steam riveter, with capacity to drive rivets up to 1 inch diameter, besides the usual equipments of a boiler shop. In our boat shop we have a Sellers plate planer, capable of planing plates up to 1 inch thick; four large punches, capable of punching from one-half to 1 inch steel plates; two plate-shears of similar capacity; one angle-iron shear, two universal carriage countersinking presses, two drills, one set heavy binding rolls, capable of binding easily steel plates 1 inch thick; one small set rolls, besides various small tools. In our erecting shop we have an "Allen portable pneumatic riveter," with which we have driven 1-inch rivets; also a hot-saw for trimming beams and angles; "Stowe flexible shaft drill," &c. In our saw-mill we have a saw and planer for dressing lumber, &c. We have also a pattern-shop, carpenter-shop, sheet-iron shop, paint-shop, mold-loft, all properly equipped with the best appliances and tools. We have looked over the specifications and plans, and have no hesitation in saying we have all needful facilities for the construction of the dispatch boat. Should we be the successful bidders, and the Department award us the contract, we can do all the work ourselves except the motive machinery, which we would have built on the Atlantic seaboard, by parties acceptable to the Navy Department. Should our record and facilities entitle us to become bidders we would like to receive as soon as possible the necessary blanks, &c. for preparing our proposals.

Very respectfully, your obedient servants,

ALLEN & BLAISDELL.

HON. SECRETARY OF THE NAVY,
Washington, D. C

COLUMBIAN IRON WORKS AND DRY-DOCK COMPANY,

STATEMENT OF MR. WILLIAM T. MALSTER.

BALTIMORE, *November* 27, 1885.

The CHAIRMAN. Please state your name, residence, and present position.

Mr. MALSTER. William T. Malster, Baltimore, Md.; president and general manager of the Columbian Iron Works and Dry-Dock Company.

The CHAIRMAN. What is the capacity of your works to build ships, engines, and boilers?

Mr. MALSTER. Capacity is large. We have about 8 acres of property, 4 of which are covered with shops, wharves, and a dry-dock. The property is surrounded by a large area of deep water, suitable for the launching of the largest ships. We also have the advantage of railroad communications which enables us to have all kinds of material delivered in our yard that are necessary to the construction of ships, boilers, and engines.

The CHAIRMAN. Have you ever built any iron or steel vessels? Please give a list of them, with their tonnage.

Mr. MALSTER. We have built several iron vessels and a number of wooden ones, viz: Holly, 400 tons; Jessamine, 400 tons; Robert Garrett, 300 tons; F. C. Latrobe, 1,200 tons; Enoch Pratt, 500 tons, and several large tugs.

The CHAIRMAN. What is the largest ship, engine, or boiler you have ever built?

Mr. MALSTER. The largest ship was 1,800 tons; the largest engine, $\frac{28'' \times 50''}{33''}$ compound. Boilers of all descriptions, the largest of 1″ iron for a 6,000-ton ship.

The CHAIRMAN. Has the Government any interest or property in the dry-dock belonging to the Columbian Company?

Mr. MALSTER. No; the Government granted us the use of the property for ever, provided a dry-dock be built thereon and kept in order.

(Refer to records of War Department (Washington), deed No. 4, pages 67, 68, 69.)

The CHAIRMAN. Does the dock belong to your company or is it leased by you?

Mr. MALSTER. The property is leased by the Baltimore Dry-Dock Company to the Columbian Iron Works and Dry-Dock Company.

The CHAIRMAN. Have you ever made any bids for Government vessels?

Mr. MALSTER. I have.

The CHAIRMAN. Please state what work you have done for the Government.

Mr. MALSTER. We built the light-house steamers Arbutus, Laurel, Holly, and Jessamine, and the revenue steamer Tenchcox. We repaired the machinery of the Tallapoosa. We have done, besides the above, a very large amount of marine repair work of every description for the Government, and have at present a Government vessel under repair.

The CHAIRMAN. Do you recall that in 1882 there were public advertisements asking all reputable manufacturers of vessels, steam engines, boilers, &c., having regular establishments, to submit plans, models, and designs to the Naval Advisory Board? Did you submit any?

Mr. MALSTER. I did not.

The CHAIRMAN. Please state your reasons for not doing so.

Mr. MALSTER. It seemed to me that it was the proper thing for the Government to make plans and specifications, and then ask for bids on the same, as no builder would care to engage in furnishing plans and specifications with the probability of having them rejected and the Government receive benefit from such portions of said plans and specifications as would suit their purposes.

The CHAIRMAN. Did you receive in 1883 a circular letter asking advice and suggestions concerning designs of vessels for which Congress was called upon to make an appropriation?

Mr. MALSTER. Yes; but I made none.

The CHAIRMAN. Are you enlarging your plant? If so, to what capacity?

Mr. MALSTER. We are not enlarging our plant and shall not do so until business justifies doing so.

The CHAIRMAN. How can the Government best build ships, engines, and boilers (whether wholly in Government works, or partly in such works and partly by contracts with private builders, or wholly in private yards)? In case of divided labors how should the division be made?

Mr. MALSTER. Wholly in private yards.

The CHAIRMAN. What would be the comparative cost of the two methods?

Mr. MALSTER. Thirty per cent. in favor of private yards.

The CHAIRMAN. Why cannot ships be built as cheaply in navy-yards as in private yards?

Mr. MALSTER. Because men will not work as hard in navy-yards as in private ones; delays arise in transmitting orders; there is an apathy of foremen who have secured their positions by political influence; too much time is spent on precision; and there are many men who do no other work than attend roll-call.

The CHAIRMAN. Has the eight-hour law any influence on this question?

Mr. MALSTER. An immense influence. The difference is two hours per day for every man employed, all private yards requiring ten hours for a day's work.

The CHAIRMAN. Which are the best locations for the performance of the work indicated in the resolution?

Mr. MALSTER. Baltimore, New York, Philadelphia, and the Delaware River.

The CHAIRMAN. Has Baltimore any advantages over New York or any place on the Delaware River for the production of ordnance or war ships?

Mr. MALSTER. Baltimore has many advantages over them for shipbuilding by reason of its proximity to the iron and coal fields of Pennsylvania, Indiana, and Virginia; superior wood material; cheap labor; less cost of living; a better climate, which permits outside work more days in the year; proximity to the capital, which is an advantage in settling questions promptly without the formality of department routine; plenty of water, and the best harbor in the world.

The CHAIRMAN. Please state what you know of the forging or rolling-mill capacity of the United States.

Mr. MALSTER. Iron can be rolled and shafts forged in the United States for the largest ships.

The CHAIRMAN. Where do you get your supplies for the construction of your ships, engines, and boilers?

Mr. MALSTER. Ship plate is furnished us in this city by two rolling mills. We procure forgings from Pittsburgh, West Point, Reading, Bordentown, and other places. All other material we furnish ourselves.

The CHAIRMAN. Have you given any attention to the question whether a large iron-clad, similar to those of England, could be built in this country within a reasonable time? Such an iron-clad would require very heavy steel forgings and armor plates.

Mr. MALSTER. There ought not to be any trouble in building such vessels in a reasonable time.

The CHAIRMAN. Would you be willing to undertake the building of armored ships that would be duplicates of the latest types in the British Navy?

Mr. MALSTER. I would, and be glad of the opportunity.

The CHAIRMAN. Where would you get the heavy plates and steel shafts that would be required?

Mr. MALSTER. Could not say until after the contract was signed.

The CHAIRMAN. What inducements would you require to undertake such work?

Mr. MALSTER. A full set of detailed drawings with specifications that did not conflict; an order to build the ship; a fair price; payments to be made at reasonable intervals, and a reasonable time to complete the work.

The CHAIRMAN. Do you think that ships of the type just mentioned can be built here as cheaply as in England if you had the proper plant?

Mr. MALSTER. I do not, for the reason that labor is cheaper in England than in this country; but I think the difference of cost of building ships in the two countries can be materially lessened by giving our mechanics steady work. They will work for less, and, being better and more rapid workmen, they will bring the difference to a minimum.

The CHAIRMAN. What firms in Baltimore have plants of sufficient capacity to supply war vessels of more than 2,000 tons?

Mr. MALSTER. The Columbian Iron Works and Dry-Dock Company.

The CHAIRMAN. How long would it take them to get ready to build armored ships of 10,000 tons?

Mr. MALSTER. About ninety days.

The CHAIRMAN. Have you any other suggestions to offer that will assist this committee in the direction of the resolution under which it is making its inquiries?

Mr. MALTSER. No. You seem to have covered a great many of the principal points.

CONTINENTAL WORKS, GREENPOINT, L. I.

STATEMENT OF MR. THOMAS F. ROWLAND.

GREENPOINT, BROOKLYN, N. Y.,
February 6, 1885.

The CHAIRMAN. Please state your name and present position.

Mr. ROWLAND. Thomas F. Rowland; proprietor and engineer of the Continental Works, Greenpoint, Brooklyn, N. Y.

The CHAIRMAN. Have you at any time been requested by the Government to build ships, engines, and boilers?

Mr. ROWLAND. Yes; several times. I accepted the invitations, made proposals, and generally received orders thereon.

The CHAIRMAN. What is the capacity of your works to build ships, engines, and boilers?

Mr. ROWLAND. The capacity is sufficient to build vessels of any type, or dimensions, likely to be required by the Government. I claim also to be pretty thoroughly conversant with torpedo-boat construction, and the necessary machinery, appliances, &c. I am prepared to build boilers of any required character and size, and, generally, to do any engineering work.

The CHAIRMAN. Please name the vessels of war, or engines and boilers for same, you have built.

Mr. ROWLAND. I constructed the original Monitor, the Passaic, Montauk, and Kaatskill; excepting the machinery of these vessels, which was constructed by C. H. De Lamater, of New York. I constructed the double-turreted monitor Onondaga, excepting the machinery of said vessel, which was constructed by George W. Quintard, the then proprietor of the Morgan Iron Works, New York City. I constructed the single-turreted twin-screw monitor (known as the *light-draught class*) Cohoes, excepting the machinery, which was constructed by other parties. I built the double-turreted Ericsson monitor Puritan, excepting the machinery, which was constructed at the Allaire Works, New York, of which T. F. Secor was then the president and engineer. All of the foregoing vessels were contracted for *directly* with the Government, by other parties, viz, the first four by Capt. John Ericsson and associates; the fifth by George W. Quintard; the sixth by M. F. Merritt; the seventh by Capt. John Ericsson and associates; and I contracted *with these* respective gentlemen for the production of the said vessels. I contracted *directly* with the Government to build and deliver at the New York navy-yard the iron double-ender war vessel Muscoota. This vessel I constructed complete and ready for service, with the exception of the machinery, for which I contracted with George W. Quintard, then of the Morgan Iron Works, New York. About twelve years ago I raised the sides of the monitor Kaatskill, put in new iron decks, new boilers, new joiner work, and, generally, put ship and machinery in first-class condition. A year or two later I contracted for and constructed a new iron hull and new boilers for the United States monitor Monadnock; this hull was transported to California, and there re-erected and launched. I built the impregnable chimneys for the four wooden double-turreted monitors built during the war in the navy-yards. These ves-

sels are known as the "Miantonomoh class." I constructed the impregnable pilot-house of the Dunderberg. Some four years ago I overhauled the machinery of the United States torpedo-boat Alarm, substituting for the *Fowler* propeller, with which she was equipped when constructed, a *Mallory* patent steering propeller, thereby increasing the speed of the vessel from about seven to twelve knots per hour. I have at various times done other work for the Government, but of hardly sufficient moment to record.

The CHAIRMAN. Are you enlarging your plant?

Mr. ROWLAND. Yes; for the purpose of meeting what I believe will be the increasing demands of business, and to be prepared for the production of a higher class of construction—notably, welded and corrugated boiler furnaces, &c., and generally to more effectually perform our work.

The CHAIRMAN. What experience have you had in the use of steam hammers and of hydraulic forging presses?

Mr. ROWLAND. I have had no experience in the working of hammers of great magnitude; steam hammers for ordinary forging I have used for years in my business. Much of my work in the way of forming and welding torpedoes, flasks for withstanding great pressures, and kindred vessels, I have executed by means of hydraulic machinery. These vessels I preferably form of steel, and I find no difficulty in welding the same; in fact, do it with equal or greater certainty than would be the case in welding of iron.

The CHAIRMAN. Have you ever seen the hydraulic forging press in operation?

Mr. ROWLAND. No; other than as previously answered.

The CHAIRMAN. What are the comparative advantages and disadvantages of the two systems of forging?

Mr. ROWLAND. Both systems are very useful, and all well-equipped establishments should be provided with steam-hammers and hydraulic forming and forging machinery. These appliances are suitable for work of different character, for instance, where the undertaking in hand is the production of the stem and stern posts of a first-class iron frigate, and the rudder-frame for the same, they could be wrought into shape and welded at their various joinings with more expedition and greater precision by the steam-hammer than would be the case were hydraulic machinery employed. This also is true of the formation of many parts which are requisite for the production of a steam-engine; but in case of forgings which are to be multiplied in their numbers, and which it is feasible to produce in suitable dies, hydraulic machinery is eminently preferable. It is also destined to play an important part in this country in the production of improved hollow steel shafts for marine engines, a business which is so successfully prosecuted at the establishment of Sir Joseph Whitworth, Manchester, England.

The CHAIRMAN. How can the Government best build ships, engines, and boilers?

Mr. ROWLAND. I am decidedly of the opinion that the Government should foster and develop, in private establishments, the business of naval architecture, marine engineering, and kindred sciences, the values of which in the future, as in the past, will be measured by the prominent parts they play in the preservation of the nation's honor. The Government should patronize the people, offering contracts and furnishing work to the various establishments, thereby maintaining what may be called *schools*, for the production of artisans and mechanics, whom it may command when necessary, and in no case should it go

abroad to procure appliances for the production of engines of war of any description, if it be possible to obtain them at home. Were it practicable for the Government, in its various navy-yards, to produce economical work, take apprentices to the business, and make first-class mechanics for future use, it would doubtless be exceedingly proper to do so, utilizing these establishments for the production of a portion of what is to be our future navy; but in that case, in my opinion, not more than one-third of such work should be so proportioned, the balance being given to private citizens who are willing to embark their ability and capital in such enterprises. Thus a navy would be produced, education, encouragement, and means would be afforded, to the end that, in addition thereto, a mercantile marine would probably be established which would be creditable to the nation, and the spectacle of an American steamer bound upon an offshore voyage would cease to be a novelty. I think, however, it is improbable that the navy-yards of the country will be able to compete, in score of excellence and economy, with private establishments engaged in public work, while such navy-yards are subjected to political influences which make it impossible to obtain *picked* workmen, and which workmen, under present authority of law, labor fewer hours than is the custom to require of workmen in private establishments. Then, again, the private establishments have the advantage (if they elect to assume it) of taking apprentices, keeping them through a term of years, making of those having intelligence and energy first-class and reliable mechanics, who eventually are likely to identify themselves with, and become permanent components of, the establishment. They also have the marked advantage of purchasing material as low as or lower than the Government, for the reason that sellers thereof can generally arrange with private purchasers to more readily obtain payment for their goods either in cash or by notes to meet an emergency.

The CHAIRMAN. Which are the best locations?

Mr. ROWLAND. I have never considered the question of location, for the business of ship-building, to be of prime importance, provided the same be on the Atlantic coast, within, say, three hundred miles of New York City, in either direction, and in such position as to insure protection from, and be easily accessible to, the waters of the ocean.

So numerous are the materials which, when assembled, form the completed ship, and in such vast quantities do these materials obtain over a large area of this country, that with our competitive system of transportation, the difference of the cost thereof, at points more or less distant from New York (within the limits I have assumed), is of minor significance. In my opinion, location has but little control of the cost of labor. Upon the banks of the Delaware, as at New York and the Eastern States, equally skilled mechanics command about the same rate of wages for similar work. Skilled labor demands its premium without much regard to location.

I should adjudge that location *good* which is of sufficient area, good native soil, contiguous to water of sufficient depth, and not too distant from some seaport city.

I believe that success is within the attainment of the master-builder and constructing engineer if he be endowed with ability, energy, gumption, and tact, even though the business be transacted at what might be deemed *bad* locations; and in contradistinction, I believe that without such an endowment, mortification and failure are as sure to follow, regardless of the eligibility and convenience of location.

WILLIAM CRAMP & SONS.

STATEMENT OF MR. CHARLES H. CRAMP.

PHILADELPHIA, PA., *November* 21, 1884.

The CHAIRMAN. Please state your name, residence, and present position.

Mr. CRAMP. Charles H. Cramp, president of the firm of William Cramp & Sons, Philadelphia, Pa.

Mr. MORGAN. How long has your firm been engaged in the ship-building business?

Mr. CRAMP. About sixty years. My father founded the institution in 1826. The company now consists of his five sons, who have all been bred to the profession of ship-building.

Mr. MORGAN. When did you begin to build iron ships?

Mr. CRAMP. During the war.

Mr. MORGAN. What war vessels did you build during the war?

Mr. CRAMP. We changed into a cruiser the steamer Union that was under construction at our yard on Spanish account; built the armored ship New Ironsides, the light-draught monitor Yazoo, the 4,000-ton cruiser Chattanooga, and the double-ender Wyalusing. We also built several transports that were sold to the War Department, and four transports under a contract with the Quartermaster-General.

Mr. MORGAN. Were those iron or steel ships?

Mr. CRAMP. They were all wooden ships, with the exception of the Yazoo, which was iron.

The CHAIRMAN. How about the New Ironsides?

Mr. CRAMP. She was an armored ship with wooden hull. She carried an armament of 14 11-inch smooth-bores, and 2 8-inch Parrott rifles. She was a broadside ship.

Mr. MORGAN. What war ships have you built since the war?

Mr. CRAMP. The Terror.

Mr. MORGAN. Any others for the United States?

Mr. CRAMP. No.

Mr. MORGAN. For other Governments?

Mr. CRAMP. We built the Europe for the Russians.

Mr. MORGAN. What was her tonnage?

Mr. CRAMP. Her displacement was 3,000 tons. We also built the Zabiaca of 1,200 tons displacement, and altered two merchant vessels into cruisers. One was the Columbus which we had built for the Havana trade, and which the Russians renamed the Asia. She displaced about 2,800 tons. The other was the Saratoga, built by Mr. Roach for the same trade. The Russians named her the Africa. She was of about 3,000 tons displacement.

The CHAIRMAN. Was she a cruiser?

Mr. CRAMP. Yes; all of these were cruisers, and built of iron.

The CHAIRMAN. Did you build any others for any Government?

Mr. CRAMP. Just after the Mexican war we built the Liberetador for the Venezuelan Government.

Mr. MORGAN. What steel and iron ships have you built for commerce

since the war; that is, since you commenced constructing ships of this description?

Mr. CRAMP. Do you want the names and descriptions of them all?

Mr. MORGAN. Are they numerous?

Mr. CRAMP. Quite a number.

Mr. MORGAN. About how many have you built?

Mr. CRAMP. I will give a list, but it will include only ocean-going screw steamships. We have built a good many small craft, such as tugs, &c., small yachts, and some iron side-wheel steamboats, besides iron sailing vessels, and some wooden ships, both sail and steam. The first of our iron screw steamships was the Clyde, built in 1870. She was 1,182 tons. Next was the George W. Clyde, 1,032 tons. She was the first American steamship fitted with the independent compound engine. At the time she was designed there was but one foreign vessel coming into New York with a compound engine. Then came the four ships of the Liverpool line: the Pennsylvania, Ohio, Indiana, and Illinois, of 3,104 tons each, and built in 1872-'73. Next was the Columbus, 1,583 tons, which I have already mentioned as having been bought by the Russians and altered by us into the cruiser Asia. This vessel was the type of our present iron coasting fleet. By the way, the tonnage given in this list is registered tonnage, not total displacement. Merchant vessels are always classed according to their register. Only men-of-war are rated by displacement. Then, in 1874, we built the screw colliers Reading, Harrisburg, Lancaster, Williamsport, Allentown, and Pottsville, of 1,283 tons each, for the Reading Railroad Company. In 1875, the Saint Paul, 900 tons, for the Alaska Commercial Company. In 1879, the State of California, 2,266 tons, for the Pacific Coast Steamship Company. In 1880, the Chalmette, 2,983 tons, for the Morgan Line, to run between New York and New Orleans. At this time we also built the Corsair and Stranger, yachts of 237 tons each, for parties in New York. These are among the fastest steam yachts in the world. They carry engines of more than 2 indicated horse-power to the ton of displacement. In 1881 we built the Caracas, of 1,589 tons, for the Venezuelan Line of New York, Boulton, Bliss & Co. Also four iron side-wheelers for the Long Branch, Coney Island, &c., passenger traffic; owned by the Iron Steamboat Company of New York. Their aggregate tonnage is 3,488 tons.

In the same year we built the Allegheny and Berkshire, of 2,014 tons each, for the Merchants' and Miners' Transportation Company of Baltimore, together with the City of Puebla, 2,550 tons, for Alexandre's Havana and Mexican Line.

In 1882 we built the Queen of the Pacific, 2,727 tons, for the Pacific Coast Steamship Company, the Valencia, of 1,600 tons, for Boulton, Bliss & Co., and the Tacoma and San Pedro, 3,100 tons each, for the Central Pacific Railroad Company, to be used in the coast trade between San Francisco and Oregon.

In 1883 we constructed the Mariposa and Alameda, of 3,158 tons each and 5,000 tons displacement, for the Sandwich Island trade. These are the fastest steamships in the Pacific Ocean.

In 1884 we built the San Pablo for the Central Pacific, and the Eureka, El Paso, and El Dorado, of 3,531 tons gross register and 6,152 tons displacement each, for the Morgan Line, New York and New Orleans. Also the H. F. Dimock, of 2,625 tons register and 4,420 tons displacement, to run between New York and Boston, outside passage. She is the fastest vessel on the Atlantic coast. At this time we are building the Philadelphia, of about 2,000 tons, for the Venezuelan Line. Boulton, Bliss & Co.

The San Pablo is a remarkable ship. She is of 3,119 tons register and about 6,100 tons load displacement. Her first service was to carry a cargo of petroleum and dry goods from New York, via the Suez Canal to Japan. She made the quickest passage on record from Gibraltar to Shanghai, beating the celebrated time of the crack English ship Strathmore by several days. She logged continuously over 12 knots an hour, and produced her power on the smallest relative consumption of coal on record in those seas. This was the more noteworthy, as it was done with new engines just out of the shop. Her engineer reported that she did not heat a bearing. I am advised by naval officers who saw and inspected her out there that she was admitted, even by the English officers, to be the best freight steamship ever sent into Chinese waters. I learn from recent European newspapers that the Chinese Government is trying to buy her for conversion into a cruiser. We could convert her into a cruiser at comparatively small cost. She is the fastest ship I know of, considering the relations of her horse-power to her tonnage. It is proper to say that she made her great run from Gibraltar to Shanghai on two coalings, one at Suez and the other at Singapore; and she was loaded down some 8 inches below her natural load line at that.

The large vessels we have lately built for the Morgan Line are exceptionally fine ships. They would be of immense value to the Government as transports in case of war. They are all very strong ships and are fast and handy.

To sum up, we have built since the war thirty-two iron ocean-going merchant vessels having a total tonnage of over 75,000 tons register and nearly 200,000 tons displacement, besides the war vessels, steamboats, and yachts that we have built. In these ships we have put altogether over 55,000 indicated horse-power in marine engines, all compound except that of the Clyde, built in 1870, and not one of these engines has ever broken down or become disabled by reason of defects in material or faults of workmanship. That is substantially the record of our firm in modern ship-building. I take pleasure in submitting it to the committee. If it would be of interest I might add that the yacht Atalanta, built by us for Mr. Jay Gould in 1883, of 568 tons register and 2,000 horse-power, made last August the fastest four hours' run ever made by any screw-steamer under 7,000 tons. Her time was at the rate of a seven-day Atlantic passage.

Including everything that we have launched, large and small, wood and iron, sailing and steam, our firm has built 245 vessels, most of which are now in active service.

Mr. MORGAN. Are any of these vessels steel?

Mr. CRAMP. No, sir; they are all iron.

Mr. MORGAN. Where were the engines built?

Mr. CRAMP. We built all of the engines since 1870.

Mr. MORGAN. So you built these vessels out and out?

Mr. CRAMP. Yes, sir.

Mr. MORGAN. Have you built any steel ships at all?

Mr. CRAMP. No; the hulls are all of iron, but we have built a great many steel boilers. Most of the latest vessels named in the list which I have furnished the committee have steel boilers.

Mr. MORGAN. Where did this iron which you used in building these ships come from?

Mr. CRAMP. The great bulk of it was made in Pennsylvania—in Coatesville, Reading, and Pottstown. Some of it came from Baltimore. There

is quite a large plate-mill in Baltimore, but it is not running very profitably now.

Mr. MORGAN. What do you think of the relative advantages in the use of iron and steel in the hull of a ship?

Mr. CRAMP. In the trade the term "iron-ship building" is used generically to describe all metallic ship construction. What is termed steel in connection with ship-building is technically known as mild steel, and is really nothing but iron developed, in certain directions of quality and property by certain newly-discovered processes, to a higher point of excellence than had hitherto been attained by the old-fashioned methods of puddling.

This demand for steel began in England, and was due to the degeneracy of iron which had been caused by the merciless competition of the British yards to produce cheap ships; which in turn excited competition among the rolling mills to produce cheap iron. To protect the ship-building interests of England, the present laws, Plimsoll act, and system of inspection were established. By a coincidence just at this time, the development of the Siemens-Martin process began, and its product, which was called mild steel, being so much more uniform in quality than the grades of iron that had been used, it at once received the patronage of Lloyds, and they made an arbitrary allowance of some 15 per cent. in its favor.

Mr. MORGAN. What would be the difference in thickness of iron and steel plates in a ship of 3,000 tons?

Mr. CRAMP. That would depend upon the quality of the material. The following are the English and American rules:

Quality of iron.

ENGLISH.	AMERICAN.
To be of a good malleable quality, capable of withstanding a tensile strain of 20 tons per square inch and 18 tons across the grain. (See page 66, Lloyds.)	To be of the best brands, tough and malleable. The absolute mean breaking strain to be not less than 48,000 pounds to the square inch, and all plates to bend cold, &c. (See page 56, Record.)
The English rule is based upon eleven lengths to one depth. Beyond that vessels are called of extreme proportions, which see Lloyds, 104.	The American rules are a modification, &c. (See page 47, Record.) For more than twelve depths vessel becomes of excessive proportion.

Steel.

Lloyd allows a general maximum reduction of 20 per cent. (See p. 120, and for tests, p. 121, Lloyds.)	Nothing about steel in American rules.

Mr. MORGAN. What thickness would you make the plates of a steel ship if you were going to build a powerful ship of war, had plenty of money at your command, and wanted to build a ship without reference to cost?

Mr. CRAMP. That would vary with regard to the size of the ship.

Mr. MORGAN. Say one of 4,000 tons displacement.

Mr. CRAMP. A great deal depends on how strong she would want to be, how light a draught she was to have, and how much she would be required to carry. It would depend altogether on the purpose for which she was demanded.

The CHAIRMAN. Take, for instance, a cruiser fully armed.

Mr. CRAMP. It depends a great deal upon the relative dimensions.

The CHAIRMAN. Say 4,000 tons.

Mr. CRAMP. That does not cover the ground. One ship may be 4,000 tons, and very long and narrow. Another may be short, wide, and deep. There is so much to be taken into consideration when you say thickness. If you look over Lloyd's requirements for iron ships you will find for every increase of relative length of the ship, as compared with other dimensions, you have to increase the thickness of the plates, particularly at the points of greatest strain. In order to say what thickness of plates I would put on a 4,000-ton ship I would have to know her dimensions, form, and general structure, and for what purpose she was intended.

The CHAIRMAN. What was the thickness of the four ships you built for the Philadelphia and Liverpool line?

Mr. CRAMP. They were built of eleven-sixteenth and twelve-sixteenth plates, with shear streaks fourteen-sixteenths thick. But since that time all the rules have altered in direction of thickness. If you compare Lloyd's requirements of 1872 with those of 1882, you will find they have increased all the plate thicknesses over 20 per cent. for the same dimensions of ships, besides proportionately augmenting the weight of frames.

Mr. MORGAN. Do you refer to steel or iron?

Mr. CRAMP. Iron. You will find that these rules vary, as I said, from time to time. At the time of which we are now talking there were no rules for anything but iron.

Mr. MORGAN. Where did you get the steel to make the boilers you referred to?

Mr. CRAMP. From several different manufacturers; mainly from Park Brothers and the Spang Iron and Steel Company of Pittsburgh; the Norway Works, Boston; and the Otis Iron and Steel Company of Cleveland. We got some elsewhere, but in small quantities only.

Mr. MORGAN. Did you use any foreign steel?

Mr. CRAMP. No, sir; none at all.

Mr. MORGAN. How have these boilers stood?

Mr. CRAMP. Magnificently.

Mr. MORGAN. You would say that American steel was quite adequate for making marine boilers?

Mr. CRAMP. Yes, sir.

Mr. MORGAN. Have you found any difficulty in getting a sufficient supply heretofore?

Mr. CRAMP. No, sir; the only trouble was the price; there was no trouble about getting it if you paid for it.

Mr. MORGAN. What is about the percentage of difference in cost of building an iron ship here and on the Clyde?

Mr. CRAMP. That is hard to say, because the percentage of difference there varies very much. The percentage of difference in prices there would be from 25 to 30 per cent., depending altogether on who builds the vessel. There is no fixed price for building any vessel in Scotland, or in this country at this time on account of the extraordinary dearth of orders. The great bulk of the ship-yards are practically closed.

Mr. MORGAN. Is there no decided advantage in favor of the American ship-builder over the English ship-builder in prices?

Mr. CRAMP. That is a difficult question to answer point-blank. To answer it properly, and as I would like to do, would require an essay. In England they build an English ship, and in this country we build an American ship. If you were to compel an Englishman to build an American ship he would charge as much as we do.

Mr. MORGAN. You insist that the American ship is better?

Mr. CRAMP. There are many differences in the methods of construc-

tion. The materials of the American ship average better throughout. The workmanship is better. The outfit is more complete. The accommodations for people on board, crew as well as passengers, are far superior. So that, on the whole, an American-built ship is always worth more money than an English-built vessel of the same general type.

Mr. MORGAN. Then a ship built on the American style would be rather more expensive?

Mr. CRAMP. Yes; and far superior to the English ship. I can take strong ground there.

Mr. MORGAN. Do you believe that you could duplicate the Oregon?

Mr. CRAMP. Yes; and duplicate her speed and sea-going qualities.

Mr. MORGAN. Do you know what she cost?

Mr. CRAMP. We have been informed that she cost $1,680,000. We would like to build her duplicate to-morrow for that money.

Mr. MORGAN. Is that because there has been a fall in the price of ship-building since the Oregon was built, or because you think you could make money on the contract at the same rate of wages that obtained at that time?

Mr. CRAMP. For a high order of work there has not been a great difference in prices between us and the English ship-builders. We would be glad and willing to build at the rates that the Cunard people have been giving for their ships. They always give big prices and have the best builders. We would like to fill our yard with the sort of work the Elders have been doing for the Cunard company at the same prices.

Mr. MORGAN. You think you could build ships equally as good as theirs?

Mr. CRAMP. Yes; and better as regards accommodations for the comfort of those on board, safety, and workmanship generally.

Mr. MORGAN. You feel entirely confident that you could build ships equal to any of the Cunard line?

Mr. CRAMP. Yes. We made the offer to the president of the Cunard company, Mr. John Burns. He visited Mr. Gould's yacht at our yard and told me he was giving $30,000 more for his yacht than Mr. Gould was paying for his. I told him that over 95 per cent. of the business of the Cunarders had been derived from Americans, and that it would be a compliment to their chief patrons to build one of their new ships here. We offered to duplicate the Servia for the same price, and guaranteed to beat her time across the ocean. This rather startled him, and he said the matter had never been presented to him in that light. But he took good care to have his last two vessels built on the Clyde. That was a *bona fide* offer from one business man to another. He wanted new ships, we wanted work, and every proposition I made meant business. Our firm still holds that offer open to Mr. Burns or to anybody else. We will undertake at any time to duplicate any of the higher classes of English work at English prices.

Mr. MORGAN. Do you know the cost of the English iron-clads?

Mr. CRAMP. No, sir; not in detail. I have all the data, but they are among my papers of reference, and I have not committed them to memory.

Mr. MORGAN. Do you think you could duplicate those ships?

Mr. CRAMP. Yes, sir.

Mr. MORGAN. Where would you get the armor-plates?

Mr. CRAMP. To-day, we would have to get the armor-plating abroad, but I am satisfied that if there was any encouragement given to people in the business on this side we could get as good armor plating here as abroad.

Mr. MORGAN. It is only a question of machinery, I suppose.

Mr. CRAMP. No, not of machinery alone; but of encouragement to the skill which is among us. But it must be in the hands of somebody familiar with the business of handling large masses of metal, and conversant with the processes of fabrication.

Mr. MORGAN. If the United States should give orders for several large ships, duplicates of the heavy iron-clads of the English navy, do you think that they could be built here, after putting up the necessary plant and machinery?

Mr. CRAMP. We would not have to put up any additional plant to duplicate the ships referred to.

Mr. MORGAN. I speak of armor-plates.

Mr. CRAMP. We are not in the manufacture of armor-plates. We are ship builders. We put them on, but it is not the province of any ship-builder to manufacture armor-plates.

Mr. MORGAN. The question I am putting is whether you would be willing and able in this country to build armored ships which would be duplicates of those in the British navy at the same price as that government paid for them?

Mr. CRAMP. We would not, at this time, if compelled to get extremely heavy armor-plates in this country to fill an immediate order. Whether we could eventually get it at any reasonable figure, would depend upon the encouragement which the policy of the Government might give to American manufacturers. You must remember that the Government would be the only possible customer for armor-plate, and it would require large orders to induce investment in the expensive plant required. Medium weight, say under ten inches thick, could be produced here very soon, if there was any demand. Then we must consider the controversy between the advocates of compound armor and of all steel. I find that the Schneider plates, which are all steel, in the experiments lately at Spezzia and also at Gavre, stood the best test of all the plates tested at that time; and I am satisfied that as good plates can be made in this country as the Schneider plates.

Mr. MORGAN. Suppose armor-plates could be furnished as cheaply here and as good, then could you make those ships as cheap here as the English Government got theirs?

Mr. CRAMP. I think so.

Mr. MORGAN. The making of the armor-plating is the only difficulty not provided against?

Mr. CRAMP. That is one difficulty; but I do not see why the Government should insist that the price of armor-plates should in the beginning be the same here as abroad. Competition and development would naturally bring the price down.

Mr. MORGAN. But the only difficulty in making armor-plates here is because we are not provided with the necessary machinery here as abroad. So far as the hull and equipment are concerned do you think you could build the ships as cheaply here as the British Government can?

Mr. CRAMP. Yes, sir.

Mr. MORGAN. You have never engaged in the manufacture of steel, have you?

Mr. CRAMP. No, sir; that is another business entirely. It is a great deal better for people to excel in a single industry than to be sprawling about in a desultory manner as Jack-at-all-trades and master of none.

Mr. MORGAN. You get all your supplies, both of steel and iron, from other parties?

Mr. CRAMP. Yes, sir; and at much better advantage than by attempt-

ing to make them ourselves. I regard that proposition as a fundamental rule of business.

Mr. MORGAN. Where were the heavy machine tools in your ship-yard made?

Mr. CRAMP. Mostly in Philadelphia. Our largest planer was made at Bridgewater, Mass.

Mr. MORGAN. There are no foreign tools in your yard, therefore?

Mr. CRAMP. We have one punch which was made abroad.

Mr. MORGAN. Is it a large one?

Mr. CRAMP. It was of a peculiar pattern which we needed, and we bought it because we wanted such a tool at once, and could not wait to have it made. We could build a medium-sized ship, engines and all, while such a punch was being made.

Mr. MORGAN. Could that tool be duplicated in Philadelphia?

Mr. CRAMP. Yes; I have no doubt of it.

Mr. MORGAN. You would find no occasion, then, in building ships, to go abroad for the machine tools?

Mr. CRAMP. No.

Mr. MORGAN. And in that you include, of course, the building of marine engines?

Mr. CRAMP. If we were required to furnish steel shafting of large size, with solid coupling, we might have to go abroad for them for some time yet. The principle that I have already stated to apply to armor-plate applies to steel shafting.

Mr. MORGAN. Why is that?

Mr. CRAMP. The hammers here are not large enough. We can get plain steel shafting, without solid coupling, very easily, but two or three firms on the other side have made a *specialty* of steel shaftings, with solid coupling, and therefore they make them very fine.

Mr. MORGAN. In preparing for the business of building ships is it necessary to have a number of skilled mechanics?

Mr. CRAMP. That is indispensable.

Mr. MORGAN. A great deal of your success in building ships would depend upon the character of the men employed in your works?

Mr. CRAMP. Yes, sir.

Mr. MORGAN. Have you in your employ any American educated ship-builders and mechanics?

Mr. CRAMP. We have some first-class mechanics who are Americans. Most of our best mechanics are Americans.

Mr. MORGAN. Do you see any difference in the methods of construction, or capacity of the men, to the detriment of Americans in the different classes of work in which you have to use them? Are the Americans at any disadvantage, as compared with foreigners, in learning all the ways of ship-building?

Mr. CRAMP. No, sir. They have every facility in this country that can be found abroad, and, in addition to that, they have the incentive of better wages, and the encouragement of better living than foreign mechanics.

Mr. MORGAN. Do you think that you could organize in your ship-yard here, for the purpose of building steel armor-plates, a force of Americans who would be competent for the business?

Mr. CRAMP. No ship-builder anywhere in the world should undertake the manufacture of armor-plate. That is another industry.

Mr. MORGAN. I speak now of the skilled men.

Mr. CRAMP. Oh, yes.

Mr. MORGAN. Do you think you could organize a force of men competent to do the work in building a steel armored ship of war which would be composed entirely of Americans?

Mr. CRAMP. We have an organization of *that* kind now, so far as the higher order of skill is concerned. Our common laborers now are largely foreign or imported.

Mr. MORGAN. Do you mean that your present organization is composed entirely of Americans?

Mr. CRAMP. They form the foundation of our present organization. I will explain in this way. We have about twenty-five head foremen; they have subordinate foremen, and then there are two or three men under each of them whom we are obliged to keep. We won't let them go. You can't pick them up after you let them go. They are drilled, not only in their business, but in our usages, and know how to conform to our peculiar system. We have our own system of doing work, as other people have theirs. Some of the foremen have been brought up from boyhood with us.

Mr. MORGAN. Then I understand you to say that the great body of skilled workmen in your yard are Americans.

Mr. CRAMP. Yes, sir.

Mr. MORGAN. And you would find no difficulty in obtaining Americans in sufficient numbers with sufficient skill?

Mr. CRAMP. None whatever. Give us the work to do and we will find the men.

Mr. MORGAN. The point I am trying to get at is if there is any real necessity of going abroad for workmen to build steel ships.

Mr. CRAMP. There is no necessity for that. We could organize two or three establishments out of our own yard.

Mr. MORGAN. You mean by that that you could have two or three ships building at the same time?

Mr. CRAMP. No, two or three entire establishments. If we had three large ship-yards in hand we could make three large first-class independent establishments out of our own force.

Mr. MORGAN. Any event, then, that would break up this organization, that you have perfected after so long a time, would be injurious to steel and iron ship-building?

Mr. CRAMP. Yes; injurious to ship-building and injurious to American industry.

Mr. MORGAN. And injurious to the men?

Mr. CRAMP. It would of course be injurious to the men if their business was destroyed. Some of our first-class engineers and machinists could get work at other places and on other classes of work, but not such wages, because marine engineering is the finest, most difficult, and most perfect of all engine work. The compound marine condensing-engine is the most complete of all engines, and the most of our men are exceptionally expert and very efficient.

Mr. MORGAN. Where is the Terror now?

Mr. CRAMP. At our wharf.

Mr. MORGAN. In what condition?

Mr. CRAMP. Without her armament, armor-plating, or turret.

Mr. MORGAN. Has the plan for the turret been determined?

Mr. CRAMP. I do not know. I know the plans have been made, but whether accepted by the Board or not, I cannot say.

Mr. MORGAN. What is the draught of the Terror?

Mr. CRAMP. The mean load draught of the Terror is 13 feet 3 inches.

Mr. MORGAN. Is her hull of iron or steel?

Mr. CRAMP. Iron; but a very superior kind of iron.

Mr. MORGAN. Is she a strong ship?

Mr. CRAMP. Yes, as strong as any ships that I have seen abroad, of her class. I have seen a majority of the iron-clads abroad, and have examined some of them while building.

Mr. MORGAN. Is there any establishment in this country that could make the armor-plating for the Terror?

Mr. CRAMP. It has not been determined what kind she is to have yet. I think the Moorheads could make 7-inch plates. They could roll 7-inch steel plates if they could get the ingots. It is my understanding that 7-inch armor plates could be made now. I have information that Park Brothers have undertaken to roll a test plate of compound steel, 13 feet 9 inches long, 44 inches wide, and 7 inches thick.

Mr. MORGAN. That is as high as they could go, is it?

Mr. CRAMP. I do not know about that. They might go higher, but within a year I am satisfied they could go as high as you like, if you would adopt a policy that would guarantee them the necessary orders.

Mr. MORGAN. Why do you say within a year?

Mr. CRAMP. I heard the Moorheads say four or five years ago that they could alter their mill and have it ready in less than a year to roll large plates 15 inches thick. But my information about the capacity of Park Brothers is very recent, but second-hand. I should say that the Midvale Works, Park Brothers, the Miller Forge Company, of Pittsburgh; the Paterson Iron Works, of Paterson, N. J.; the Otis Works, the Norway Works—perhaps six or seven different steel-forging establishments in the country—would be ready to undertake to supply any demand the Government might make in the direction of armor-plates, provided they were guaranteed sufficient orders to make it worth while to erect the necessary additional plant.

Lieutenant JAQUES. Here is an official answer to your question.

1.—CIRCULAR.

NAVY DEPARTMENT,
Washington, June 20, 1884.

GENTLEMEN: The completion of the monitors Puritan, Amphitrite, Monadnock, and Terror will undoubtedly be authorized by Congress, and the Department is therefore desirous of obtaining early information pertaining to the armor-plates for the above vessels, and requests you to inform it whether or not you will be prepared to manufacture such armor or any portion thereof, and the earliest date after signing a contract at which you can deliver the same.

The amount of armor that will be required is about 3,000 tons, and it will be required in shape suited for side armor, turret-plates, smoke-pipe-plates, and ventilator-plates. The thickness of the plates will vary from 6 to 17 inches, and a large number of them will be tapered in form. The other dimensions will vary from 15 feet to 24 feet in length and from 6 feet to 7 feet in width.

As it is desired that there shall be the freest competition, the specifications will admit bids for either all steel or compound armor, and this preliminary notice is given so that the Department may have the earliest notice of the probability of receiving bids from American manufacturers.

Each bidder will probably be required to submit with his bid a specimen plate 7½ feet square and of the maximum thickness which he proposes to furnish, which will be tested in open competition according to the method that may be prescribed for acceptance.

Letters of inquiry on this subject will be promptly answered.

WM. E. CHANDLER,
Secretary of the Navy.

LIST OF STEEL WORKS TO WHICH THE CIRCULAR WAS SENT.

Nashua Iron and Steel Company, Nashua, N. H.
Bridgewater Iron Company, Bridgewater, Mass.
*Norway Steel and Iron works.
Naylor & Co., 6 Oliver street, Boston, Mass.
*Albany and Rensselaer Iron and Steel Company, Troy, N. Y.
Newark Steel Works, Newark, N. J.
*New Jersey Steel and Iron Company, Trenton, N. J.
*Midvale Steel Company, Nicetown, Philadelphia, Pa.
Bethlehem Iron Works, Bethlehem, Pa.
Pennsylvania Steel Works, Steelton, Pa.
*Standard Steel Works, 220 South Fourth street, Philadelphia, Pa.
Black Diamond Steel Works.
Park Brothers & Co., Pittsburgh, Pa.
Edgar Thomson Steel Works, 48 Fifth avenue, Pittsburgh, Pa.
*Pittsburgh Steel Works, Pittsburgh, Pa.
Spang Steel and Iron Company, limited, Pittsburgh, Pa.
Cambria Iron and Steel Works, Johnstown, Pa.
*Tredegar Iron and Steel Works, Richmond, Va.
*Cleveland Rolling Mill Company, Cleveland, Ohio.
*Otis Iron and Steel Works, Cleveland, Ohio.
Portsmouth Iron and Steel Works, Portsmouth, Ohio.
North Chicago Rolling Mill Company, Chicago, Ill.
*Springfield Iron Company's Iron and Steel Works, Springfield, Ill.

REPLIES.

Norway Steel and Iron Company, 23 Mason Building, Boston, June 23, 1884.—"We have no means of rolling the armor-plates referred to in your communication."

The Albany and Rensselaer Iron and Steel Company, Troy, N. Y., June 25, 1884.—"We regret that our plant lacks the proper facilities for turning out the material required, therefore are unable to submit samples for testing in competition with others.

The New Jersey Steel and Iron Company, Trenton, N. J., June 21, 1884.—"Our machinery and plant is not adapted to the manufacture of armor-plate of the dimensions described, and we could not advantageously undertake to manufacture."

The Midvale Steel Company, Philadelphia, June 24, 1884.—"We have received the Department's circular letter, dated June 20, 1884, covering an inquiry for armor-plate for the monitors Amphitrite, Puritan, Monadnock, and Terror, contents of which have our careful attention. Will you be good enough to inform us as to the longest time which can be allowed for the delivery of the first plate? We desire to know this, because certain preparations would be necessary before we could undertake any such work."

The Standard Steel Works, 220 South Fourth street, Philadelphia, Pa., June 21, 1884.—"We are in receipt of your favor of the 20th instant, asking for bids on armor-plate; but as we are not manufacturers of the article we shall be unable to comply with your request."

Anderson, DuPuy & Co., Pittsburgh Steel Works, Pittsburgh, Pa., June 27, 1884.—"We beg to acknowledge your favor of inquiry under date of June 20, with reference to armor-plates. Replying thereto, we beg to say we are not prepared with our present machinery to handle the heavy plates necessary under this call. As the Department recently, we believe, purchased such plates, will you be kind enough to inform us of the approximate market charge made to our Government by the foreign manufacturers of this class of steel that we may better inform ourselves of the advisability of looking towards its manufacture? And, further, will you be kind enough to inform us as to the impression of our Government regarding the two kinds of plate, those of solid steel, like Messrs. Schneiders, or the compound plates as made by the English?"

The Tredegar Company, June 24, 1884.—"This company is not prepared to make armor-plates of the dimensions you describe."

Cleveland Rolling Mill Company, Cleveland, Ohio, June 25, 1884.—"We have not the plant for rolling armor-plate thick enough for the purpose named."

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*Replied.

Otis Iron and Steel Company, Cleveland, Ohio, July 1, 1884.—"We are prepared to cast plates up to 40 tons in weight, but cannot roll plates over 2 inches thick."

Springfield Iron Company, Springfield, Ill., July 18, 1884.—"I am sorry to have to say that we have no rolls at present heavy enough to make the kind of plates which you will require. Neither do we at present contemplate the erection of such a train of rolls."

PARK, BROTHER & CO., LIMITED,
Pittsburgh, Pa., December 8, 1884.

WILLIAM METCALF, Esq.,
City:

DEAR SIR: We are in receipt of your favor of the 5th instant, and in reply would say * * *

We can roll a plate, say, 110 inches wide by 60 feet long, and from one-quarter inch up to 1¼ inches thick.

Yours, truly,

PARK, BROTHER & CO. (*Limited.*)
WILLIAM G. PARK, *Chairman.*

REPLIES TO QUESTIONS OF STEEL MANUFACTURERS.

NAVAL ADVISORY BOARD, NAVY DEPARTMENT,
Washington City, June 26, 1884.

MIDVALE STEEL COMPANY,
333 *Walnut street, Philadelphia:*

GENTLEMEN: Your letter of 24th instant relating to the supply of armor-plates has been referred to this Board by the honorable Secretary of the Navy.

It is the opinion of the Board that four months from the date of the advertisement, which will be issued as soon as an appropriation is made, is the longest time which can be allowed for the delivery of the test plates.

Very respectfully,

E. SIMPSON,
Rear-Admiral, U. S. N., President of the Board.

NAVAL ADVISORY BOARD, NAVY DEPARTMENT,
Washington City, July 1, 1884.

Messrs. ANDERSON, DUPUY & CO.,
Pittsburgh, Pa.:

DEAR SIRS: Your letter of 27th ultimo has been referred to this Board by the honorable Secretary of the Navy, and in reply we have the honor to forward a copy of the report of the Secretary of the Navy for 1883, in which, under the head of "armored vessels," you will find the prices paid for the turret armor of the Miantonomoh. Senate Ex. Doc., No. 144, also inclosed, gives further information on the subject.

The Department does not at this time express any preference for all steel or for compound armor.

If you deem this matter of sufficient interest to send a representative of your firm to Washington I shall be glad to furnish him with all information in my hands.

Very respectfully,

E. SIMPSON,
Rear-Admiral, U. S. N., President of the Board.

NAVAL ADVISORY BOARD, NAVY DEPARTMENT,
Washington City, July 5, 1884.

OTIS IRON AND STEEL COMPANY,
Cleveland, Ohio:

Mr. J. K. BOLE:

DEAR SIR: Your letter of 1st July, in reply to the Department's circular of 20th ultimo, has been referred to this Board. Will you please inform the Board, in case proposals for armor are asked, whether you will submit a plan for test or not.

Very respectfully,

E. SIMPSON,
Rear-Admiral, U. S. N., President of the Board.

NOTE.—No reply has been received to the last letter.

Mr. MORGAN. Does that refer to the size and character of the rolls?

Lieutenant JAQUES. The size and character of the plates were indicated, but the kind of armor was not. That was left to the manufacturer.

Mr. MORGAN. I supposed the only thing necessary would be larger rolls.

Lieutenant JAQUES. It would take longer to acquire the experience necessary in manufacturing the armor than to construct the rolls.

Mr. MORGAN. You mean for our workmen to acquire the experience?

Lieutenant JAQUES. Yes, sir.

Mr. MORGAN. If we could import workmen from foreign countries, who are already experienced, we could get rid of that difficulty.

Mr. CRAMP. I do not think there would be any trouble in getting good mechanics abroad. I spent some time in British ship-yards and soon picked out who were the best workmen there and managed to get interviews with them. I asked them what wages they were getting, and whether they would like to go to the United States if they could get a better rate of wages. In every case they said they would be very glad to come. I recollect I saw a man bending the most difficult kind of steel plates. I found that man was only getting $1.75 a day, and he had a gang of eight men under him. They were getting a dollar. Now, men like that in our yard would get $3.50 and $4 a day. I found every time I have been over there, in the course of the last ten or fifteen years, that there would be no trouble in getting good men.

The CHAIRMAN. Mr. Jaques, you may ask Mr. Cramp such questions as you think proper.

Lieutenant JAQUES. Mr. Cramp, are your steamship shafts now all made of steel or of iron?

Mr. CRAMP. Of iron. We had the Tacoma's and the San Pedro's crank-shafts made of steel. They were built-up crank-shafts.

Lieutenant JAQUES. Who forged them?

Mr. CRAMP. The Midvale Steel Company.

Lieutenant JAQUES. Do you remember the weight of the largest shaft in any of your ships?

Mr. CRAMP. I think these crank-pins were 16 inches in diameter. But we wanted to get the long sections of the shafts. We would have put all-steel shafts in those two steamships if we could have got them forged with solid couplings in this country. We went to all the steel establishments in the United States, and none of them would undertake to forge a shaft with solid couplings. The crank-shafts, with solid couplings, made at Midvale, were in short pieces; but, of course, being crank-shafts, they were short, and did not require the handling of such large ingots as the long sections would have required.

Lieutenant JAQUES. Are you enlarging your present plant or are you liable to do so?

Mr. CRAMP. No, sir; we have a very large plant now. If we get a particularly large contract the enlargement of our plant would be a matter of no moment, merely the addition of a few more small tools.

Lieutenant JAQUES. What is the best system or method of providing facilities for building war-ships? Do you think it more economical to build them in navy-yards than in private ship-yards?

Mr. CRAMP. It is a great deal more economical to build them in private than in Government yards.

Lieutenant JAQUES. Which do you consider the best locations for ship-building?

Mr. CRAMP. Ship-yards ought to be near large cities, where an abundance of labor can be secured very easily. But it should always be taken into consideration that there must be sufficient depth of water in the harbor.

Lieutenant JAQUES. I think you can make that a little more explicit, taking into account supplies, coal, &c.

Mr. CRAMP. You can get supplies and coal in New York as cheap as in Philadelphia, but it is more expensive and more troublesome to handle; I would never advise New York as a place to start any kind of a large manufacturing establishment.

Lieutenant JAQUES. Why not?

Mr. CRAMP. For several reasons. For example, the character of the workmen is not so good, and they are not so easily handled as in some other localities; wages are higher, and the real estate on which a yard would stand would be very expensive. The Delaware River is the best adapted river in the United States. Baltimore would be a very good place, but the men there are very troublesome. They are nearly all foreigners, and not very good workmen. Baltimore is a place where material is as cheap as on the Delaware, but it would not be so easy for us to build ships in Baltimore as in Philadelphia; still they could be built there.

Lieutenant JAQUES. My question included a consideration of all those points—skilled labor, proximity of material, advantages of site, &c.

Mr. CRAMP. Baltimore fills all those conditions, except skilled labor. With a good organization, however, you can always get skilled labor to go from one city to another in this country, not more than fifty or one hundred miles apart. And if men know that your establishment is going to be permanent and liable to last for years, they will go and live near it.

Lieutenant JAQUES. Then you believe Baltimore to be as suitable as any place on the Delaware River?

Mr. CRAMP. No. Philadelphia is filled with skilled workmen, of superior character and habits. When speaking of the possibilities of Baltimore and other places, it must always be understood that they are not to be mentioned as rivals to Philadelphia; only secondary.

Lieutenant JAQUES. Then you regard Philadelphia and its vicinity superior to all other locations?

Mr. CRAMP. Certainly. But notwithstanding all the natural and artificial advantages of the Delaware River for ship-building enterprises, the location of a Government constructing yard anywhere along its waters would inevitably ruin the entire system of private yards there. This comprehends the whole river. If they were to start ship-building at the League Island yard, it would be equivalent to blowing up the yards at Philadelphia, Camden, Chester, and Wilmington.

The CHAIRMAN. Is that because of the eight-hour law?

Mr. CRAMP. Not only that. The men in Government employ feel that they are not expected to work, and they don't work as they are wont to do when in private employ. They only go through the motions. That is not the fault of the men, but of the system, and it can't be remedied. It is traditional. A navy-yard must always employ four or five times more labor, to accomplish a given result, than a private yard would employ, and at proportionate cost.

Mr. MORGAN. You consider the Government a dangerous rival, then.

Mr. CRAMP. I would not consider it a matter of business rivalry. It would be a species of hostile invasion. At all events, it would be a direct attack, by the Government, upon a single industry. The ship-building industry on the Delaware has grown up in spite of the neglect

of the Government. Whatever may have been past policy, it cannot be maintained that the Government has ever done anything to foster the ship-building industry that has grown up on the Delaware. The ship-builders there have gone on investing millions in plant, and by years of patient care and tireless energy have perfected the complex and difficult organizations of men and material, of skill and enterprise, of muscle and machinery, that go to make up a modern ship-yard. And now is the Government to come in, with its colossal resources in money and power, to break up these organizations, demoralize our forces, and avail itself of the skill that we have trained and the aptitudes that we have developed? I think it ought to be a settled principle and a consistent doctrine in the conduct of public affairs that the Government has no right, no moral right I mean, to engage in any manufacturing industry on its own account; but to depend wholly on the resources of its citizens. This is my conception of what should be the true policy of a free country with respect to industrial affairs.

The CHAIRMAN. You would not mind any other private yard on the Delaware, would you?

Mr. CRAMP. No. That is legitimate competition, which is a part of business, and for which we are always prepared.

The CHAIRMAN. I presume it is like any other manufacturing business. Take, for instance, my State. You start a branch of manufacture there. They do not mind if there are ten establishments in the same town.

Mr. MORGAN. I understand that Philadelphia has a very large class of artisans, and that the mechanical classes are well provided with homes?

Mr. CRAMP. Yes, sir. There can be no doubt that a greater proportion of workingmen in Philadelphia own their homes than in any other industrial center in the world, and that they live in a state of greater comfort and happiness than is the case anywhere else. The condition of the Philadelphia workingmen is often made a theme of admiration in the works of social economists.

Mr. MORGAN. Do you know of any other place in the United States where the mechanics are as well cared for as in Philadelphia?

Mr. CRAMP. No, sir.

Mr. MORGAN. It is the boast of the city, is it not?

Mr. CRAMP. Yes, sir.

C. H. DE LAMATER & COMPANY.

STATEMENT OF MR. GEORGE H. ROBINSON.

NEW YORK, *February* 5, 1885.

The CHAIRMAN. Please state your name and present position.

Mr. ROBINSON. George H. Robinson; member of the firm of C. H. De Lamater & Co.

The CHAIRMAN. Have you, at any time, been requested by the Government to build ships, engines, and boilers?

Mr. ROBINSON. Yes; and made bids.

The CHAIRMAN. What is the capacity of your works to build ships, engines, and boilers?

Mr. ROBINSON. Our capacity for making engines and boilers is equal to any establishment in the United States. To build ships, we have not suitable ground space.

The CHAIRMAN. Please name the vessels of war, engines and boilers for the same, that you have built for the Government.

Mr. ROBINSON. I mention the following as some of the most important engine-work we have done: We built the machinery for the original Monitor, which was built by the De Lamater Iron Works in ninety days from the time of signing the contract. The Dictator we built entire, both the hull and the machinery; also the following monitors: Passaic, Montauk, Catskill, Kalamazoo, and Passaconaway; we built the entire machinery for the Stevens Battery; in 1869 we built thirty gunboats for the Spanish Government, which boats each carried a 100-pound Parrott gun; these boats we built under contract in thirty weeks, building them entirely at our works. We speak of this contract and of the monitors to evidence our capacity for doing work, and doing the same in quick time. We built two steamers for the Japanese Government, the Kuroda and the Capron, in 1873, and we have built, as the De Lamater Iron Works, two hundred and forty-eight marine engines.

The CHAIRMAN. Are you enlarging your plant?

Mr. ROBINSON. No.

The CHAIRMAN. Have you any tools and implements for the manufacture of guns similar to those mentioned in the Gun Foundry Board's Report, pages 40 to 44? Can you manufacture such tools, equal in power and feed, at the cost stated therein; and how much time would you require to furnish them?

Mr. ROBINSON. We are compelled to say that while we have the capacity to build the tools, we have not the information that would warrant us in giving a price for the same or the time required to build them.

The CHAIRMAN. How can the Government best build ships (whether wholly in Government works, or partly in such works and partly by contracts with private builders, or wholly in private yards)? In case of divided labors, how should the division be made?

Mr. ROBINSON, I believe that the Government can be best served by building its vessels of war entirely in private yards and with private engine-builders. I do not see where any advantage can accrue to the Government in building its own ships in the navy-yards. My reasons

are based upon the fact that the work can be constructed at less expense to the Government and in shorter time. The rates of wages paid in the navy-yards are higher than those paid by private parties. We work 25 per cent. more hours during a day, and I believe that more work is done in the same time by workmen in private yards. There is every incentive to see that the most is produced that can be produced, and this cannot be the case in a Government yard where the interest of the workman is only in a small way identical with that of the employer. If we, as private individuals, are successful it means good employment for our workmen. The experience of all establishments shows that those concerns that do the best work in the shortest time are the concerns that are always busiest. From the very nature of the case, the workmen in navy-yards "spin" out whatever work they may have in hand. I do not wish to be understood as criticising any individual management, but I know what takes place in my own establishment in dull times and what I have to guard against, and I do not believe that the same reasons can weigh in the navy-yards that weigh with me individually.

Another ground for my belief is, without going into details which I could furnish if required, the fact that England, with all of her well-equipped navy-yards, has for years constructed all of her ships of war in private yards. This was done after faithful trials, and England still pursues the same policy.*

The CHAIRMAN. Give an opinion of the comparative cost of these methods.

Mr. ROBINSON. I believe that either ships entire or the motive power for same can be built to-day for fully 20 per cent. less in private yards than they can be built in the Government navy-yards.

The CHAIRMAN. Which are the best locations?

Mr. ROBINSON. I believe that the port of New York is as good a location for the building of ships or the machinery for same as can be found in the United States. In New York City land is too valuable to be used for ship-yards, but the establishments in New York City fitted to produce the heaviest machinery for Government vessels can turn the same out at a lower price than establishments located at any other points in the United States. New York is the center for materials and labor, and they can always be had in New York as reasonably as at any other place that I am aware of. There are a number of locations around the harbor of New York where land can be had and where, I believe, ship-yards could be maintained to as good advantage as in any location the United States affords.

* See page 103 *et seq.* (Chairman.)

STATEMENT OF MR. JOHN H. DIALOGUE.

CAMDEN, N. J., *November* 5, 1885.

The CHAIRMAN. Please state your name, residence, and present position.

Mr. DIALOGUE. John H. Dialogue; proprietor of my engineering and ship-building yard, Camden, N. J.

The CHAIRMAN. Have you at any time been requested by the Government to build ships, engines, or boilers?

Mr. DIALOGUE. I have.

The CHAIRMAN. What is the capacity of your works to build ships, engines, and boilers?

Mr. DIALOGUE. With my present facilities about four complete freight ships of from 2,000 to 2,500 tons each, provided the entire work is to be performed in my own yard; but have capacity and facilities to build a larger number if parts of the work are sublet, which method some ship-builders follow. The works embrace 2,000 feet front on Delaware River, with 28 feet depth of water at piers, and comprise offices, mold loft, pattern and joiner shops; foundry, with 20-ton crane, cupolas, ovens, and suitable pit; machine shop, containing 25-ton crane, planers, drills, 36-inch, 48-inch, and 60-inch lathes; boiler shop, with its punches and shears; steam-riveter; steam forge of small hammers; well-built shed, containing plate planers, angle-iron and plate furnaces, bending rolls, punches, and shears; and boilers and engines of adequate power. I make all my own patterns, joiner work, ordinary forgings, brass and iron castings; build the hulls; finish complete the engines and boilers, and put them in, and finish everything ready for sea. I have employed 700 men in this yard, and could now employ 1,000 without increasing my facilities. If it were required, I could furnish tools and machinery in all the departments for a much larger number.

The CHAIRMAN. Have you ever built any vessels of war, or engines or boilers for the same?

Mr. DIALOGUE. I have.

The CHAIRMAN. What war vessels did you build during the war?

Mr. DIALOGUE. The hulls of the United States steamer Monocacy and the monitor Warsaw.

The CHAIRMAN. Were they iron or steel ships?

Mr. DIALOGUE. Iron.

The CHAIRMAN. Are you enlarging your plant?

Mr. DIALOGUE. I am.

The CHAIRMAN. What are the comparative advantages and disadvantages of the two systems of forging, steam hammer and hydraulic press?

Mr. DIALOGUE. From my own personal experience I cannot say, but prefer the steam hammer for forging iron and the hydraulic press for steel.

The CHAIRMAN. How can the Government best build ships, engines, and boilers (whether wholly in Government works, or partly in such works and partly by contracts with private builders, or wholly in private yards)? In case of divided labors how should the division be made?

Mr. DIALOGUE. I am of the opinion that they should be built entirely in private works by contract: and that estimates should be agreed upon in the same manner as when contracts are made by individuals; there should be supervision of workmanship and quality of materials; there should be no radical changes in the plans after they have been adopted and agreed upon; and no more burdensome terms should be exacted from contractors by the Government than one private individual would demand from another.

The CHAIRMAN. Give an opinion of the comparative cost of the methods cited in the last question.

Mr. DIALOGUE. I estimate that it will cost twice as much to build a vessel in a Government yard as it will in a private one. And further, that the Government will have to pay contractors a very much larger price for work done than private parties pay each other until the Government treats the contractors the same as private individuals do. If it will do this, there is no reason why the Government should not get its work at the same rate as private parties, and enjoy the benefits resulting from their experience, skill, and competition.

The CHAIRMAN. Which do you consider are the best locations for building ships?

Mr. DIALOGUE. The yards on the Delaware River between Philadelphia and Wilmington.

The CHAIRMAN. How long has your firm been in the ship-building business?

Mr. DIALOGUE. I have been a member of firms in the same locality for twenty-five years.

The CHAIRMAN. When did you begin to build iron ships?

Mr. DIALOGUE. I built the monitor and the gunboat in 1862. I built the first vessel for the Treasury Department in 1870.

The CHAIRMAN. Where did this iron come from which you used in building these ships?

Mr. DIALOGUE. That for the monitor and the gunboat came from Baltimore; the rest came from Pennsylvania.

The CHAIRMAN. What do you think of the relative advantages in the use of iron and steel in the hull of a ship?

Mr. DIALOGUE. For portions of the ship I prefer steel, provided it is of the same thickness, but I prefer iron, if a reduction in thickness is made in the steel to correspond with the increased tensile strength of steel over iron.

The CHAIRMAN. What would be the difference in thickness of iron and steel plates in a ship of 3,000 tons?

Mr. DIALOGUE. The steel would be 20 per cent. lighter.

The CHAIRMAN. Where did you get the steel to make the boilers you referred to?

Mr. DIALOGUE. Most of the steel was made at Pittsburgh; a large amount came from Coatsville; and some from Chester, Pa.

The CHAIRMAN. What is about the percentage of difference in the cost of building an iron ship here and on the Clyde?

Mr. DIALOGUE. That depends upon the character of the ship; probably 30 per cent. on ordinary freight ships, and about 18 per cent. on first-class freight and passenger vessels in favor of the Clyde.

The CHAIRMAN. Have you built any steel ships?

Mr. DIALOGUE. No.

The CHAIRMAN. Do you believe that you could duplicate the Oregon?

Mr. DIALOGUE. Yes; with three months' preparation.

The CHAIRMAN. Do you know the cost of the English iron-clads?

Mr. DIALOGUE. Only from what I have read.

The CHAIRMAN. Do you think you could duplicate those ships?

Mr. DIALOGUE. Yes; but would require several months' preparation. I have yard and water facilities, but I would require some special tools.

The CHAIRMAN. Where would you get the armor plates?

Mr. DIALOGUE. In this country.

The CHAIRMAN. Please specify the rolling-mills or forges capable of making steel plates of dimensions now required by foreign Governments for their armored ships.

Mr. DIALOGUE. Messrs. Park Bros., of Pittsburgh, will prepare to furnish them in six months, or as soon as the vessel requires them.

The CHAIRMAN. If the United States should give orders for several large ships, duplicates of the heavy iron-clads of the English navy, do you think that they could be built here, after putting up the necessary plant and machinery—armored ships, which would be duplicates of those in the British navy—at the same price as that Government paid for them?

Mr. DIALOGUE. They could be built here at a slight increase in cost.

The CHAIRMAN. Suppose armor plates could be furnished as cheaply here, and as good, could you build similar ships as cheaply here as the English Government got theirs?

Mr. DIALOGUE. No; not quite.

The CHAIRMAN. Have you ever engaged in the manufacture of steel?

Mr. DIALOGUE. No.

The CHAIRMAN. Where were the heavy machine tools in your shipyard made?

Mr. DIALOGUE. Principally in Philadelphia.

The CHAIRMAN. Are there any foreign tools in your yard?

Mr. DIALOGUE. None.

The CHAIRMAN. Did you submit plans, models, or designs to the Naval Advisory Board, in response to the public advertisements in 1882, giving notice to all engineers and mechanics of established reputation, and all reputable manufacturers of vessels, steam-engines, boilers, &c., having or controlling regular establishments, and being engaged in the business, having plans, models, or designs thereof of the classes authorized by the naval appropriation act of August 5, 1882, to submit such by the 19th of October, 1882?

Mr. DIALOGUE. I did not.

The CHAIRMAN. What were your reasons for not doing so?

Mr. DIALOGUE. Because it would have required great labor with a poor prospect of obtaining any contract based on the plans furnished.

The CHAIRMAN. Did you receive in 1883 a circular letter asking advice and suggestions concerning the designs of the vessels for which Congress had made an appropriation March 3, 1883?

Mr. DIALOGUE. I did not.

The CHAIRMAN. Did you submit proposals for constructing all or any of the four ships in reply to the public advertisement of April 28, 1883?

Mr. DIALOGUE. I did not.

The CHAIRMAN. Why not?

Mr. DIALOGUE. The terms were too burdensome, and the plans were not allowed to go out of the Department. To make the necessary calculations under such circumstances would require one to be away from his works too great a length of time.

The CHAIRMAN. Have you any suggestions to offer that will assist

this committee in the direction of the resolutions under which it is acting?

Mr. DIALOGUE. I believe that the manufacture of ordnance should be made a specialty as much as any other manufacture, and that tools should be specially designed for the fitting of the forgings and castings. I think that the ships, guns, engines, boilers, and armor can all be made much cheaper, quicker, and with greater accuracy in private establishments than in Government factories. If an emergency should rise it would be impossible for such work to be produced without the assistance of private enterprise. The very best mechanics are not found in the employ of the Government, because their rate of compensation is so much lower than in private yards, and because their positions are so uncertain.

Under the present condition of affairs we cannot expect to surpass other countries in defensive means. They patronize private workshops; our Government does not to any extent in naval matters, consequently our manufacturers have no incentive to provide or develop the means. The best designs for armored vessels and ordnance in foreign countries come from private workshops, and the same would obtain here if proper encouragement were given.

I believe the only way to have the requisite work performed economically and in a reasonable time is for Congress to make a sufficient appropriation to last for several years, to be disbursed by the proper authorities having charge of that branch of the public service, and to push it rapidly to completion.

HARLAN & HOLLINGSWORTH COMPANY.

STATEMENT OF MR J. TAYLOR GAUSE.

WILMINGTON, DEL., *February* 5, 1885.

The CHAIRMAN. What is your name, profession, and present position?

Mr. GAUSE. J. Taylor Gause; iron steamship builder; president of the Harlan & Hollingsworth Company.

The CHAIRMAN. Have you at any time been requested by the Government to build ships, engines, or boilers?

Mr. GAUSE. Yes; ships, engines, and boilers, and we submitted proposals at different times.

The CHAIRMAN. What is the capacity of your works to build ships, engines, and boilers.

Mr. GAUSE. The capacity of our works is such that we would undertake the completion of any sized ship the Government might require, in readiness for armor and guns.

The CHAIRMAN. Have you ever built any vessels of war, or engines or boilers for same?

Mr. GAUSE. Yes; we built three single-turreted monitors during the war, the iron sloop Ranger, and are now building the double-turreted monitor Amphitrite.

The CHAIRMAN. Are you enlarging your plant?

Mr. GAUSE. Yes; every year we are adding to keep pace with the requirements of the times.

The CHAIRMAN. What are the comparative advantages and disadvantages of the two systems of forging, steam hammer and hydraulic press?

Mr. GAUSE. My judgment would incline to the use of presses, but I have not examined the matter with sufficient care to give an intelligent opinion.

The CHAIRMAN. How can the Government best build ships, engines, and boilers (whether wholly in Government works, or partly in such works and partly by contracts with private builders, or wholly in private yards)? In case of divided labors how should the division be made?

Mr. GAUSE. The work can be done much cheaper and better in private establishments than in Government yards, simply because a first-class establishment has its complete organization, with skilled workmen, competent foremen, and responsible superintendents, first-class tools and appliances, and a reputation to maintain for good work. Personal superintendence and responsibility will always insure the lowest rate of cost. If the work was divided the navy-yards could manage the machinery better than the hulls.

The CHAIRMAN. Give an opinion of the comparative cost of these methods.

Mr. GAUSE. I think that such work will cost anywhere from 50 to 100 per cent. more in Government yards than if contracted for with first-class private establishments, for the following reasons: The wages paid in navy-yards are *always* greater than those paid in private estab-

lishments, and the Government pays for 10 hours' work per day and only gets 8 hours' labor; moreover the men working in navy-yards do 50 per cent. less work per day than if they worked in a private yard. Favoritism prevails in navy-yards which is most pernicious to best results. Many other reasons could be given which aid in producing the results named.

The CHAIRMAN. Which are the best locations?

Mr. GAUSE. The best location is where you can get skilled labor and materials cheapest, with a favorable climate, and where the works would be protected in case of war with a foreign country. I think the Delaware River is superior to all others in the United States.

NEAFIE & LEVY, PENN WORKS.

STATEMENT OF MR. JACOB G. NEAFIE.

PHILADELPHIA, PA., *February* 3, 1885.

The CHAIRMAN. Please state your name and present position.

Mr. NEAFIE. Jacob G. Neafie, principal of the firm of Neafie & Levy, Penn Works, Philadelphia.

The CHAIRMAN. Have you at any time been requested by the Government to build ships, engines, and boilers?

Mr. NEAFIE. Yes; and have built a number of ships, including engines and boilers, for the United States Government.

The CHAIRMAN. What is the capacity of your works to build ships, engines, and boilers?

Mr. NEAFIE. We can build them of any size required.

The CHAIRMAN. Name the war vessels you have built.

Mr. NEAFIE. We built the machinery, engines, boilers, &c., of the sloop of war Lancaster, the Pawnee, the double-ender gunboat Pontiac; completed and fitted the hull and machinery of the sloop of war Quinnebaug; and, during the war of the rebellion, built and fitted out a number of smaller craft, transports, tugs, &c.

The CHAIRMAN. Are you enlarging your plant?

Mr. NEAFIE. Yes; to keep pace with the times.

The CHAIRMAN. Have you any tools and implements for the manufacture of guns similar to those cited in a portion of the Gun Foundry Board's report?

Mr. NEAFIE. We have no special gun tools.

The CHAIRMAN. Can you manufacture such tools, equal in power and feed, and at the estimated cost stated in that report?

Mr. NEAFIE. The manufacture of machines and tools for steel plant does not come within the scope of our special class of business. We have had no experience in that line.

The CHAIRMAN. How can the Government best build ships, engines, and boilers?

Mr. NEAFIE. By private builders.

The CHAIRMAN. Give an opinion of the comparative cost of the two methods—in private works or Government yards.

Mr. NEAFIE. Unable to say further than that private parties always manage such work with greater economy than the Government can.

The CHAIRMAN. Which are the best locations?

Mr. NEAFIE. Delaware and Hudson Rivers.

The CHAIRMAN. Why do steel manufacturers import foreign material?

Mr. NEAFIE. As we are not manufacturers of steel, we are unable to answer from our own experience.

PUSEY & JONES COMPANY.

STATEMENT OF MR. WILLIAM G. GIBBONS.

WILMINGTON, DEL., *February* 5, 1885.

The CHAIRMAN. Please give your full name and present position.

Mr. GIBBONS. William G. Gibbons. I am president of the Pusey & Jones Company, builders of iron ships and heavy machinery, Wilmington, Del.

The CHAIRMAN. Have you at any time been requested by the Government to build ships, engines, and boilers?

Mr. GIBBONS. Yes; we submitted proposals, plans, and drawings, and will be glad to do so again. We have built a number of vessels for the Revenue, Light-House, and Coast Survey Services, one for the War Department, and a large iron tug-boat for the Navy Department.

The CHAIRMAN. What is the capacity of your works to build ships, engines, and boilers?

Mr. GIBBONS. The capacity of our works is first rate. We have capacity to make with ease the heaviest machinery, castings, and tools, to do the fitting, cranes to handle, shears to lift boilers and handle machinery, and wharves at which vessels can lie while receiving the same.

The CHAIRMAN. Name the vessels of war, or engines for same, that you have built for the Government.

Mr. GIBBONS. The engines for the sloop Juniata, gunboats Wyalusing and Mingoe, and the second-rate Shackamaxon. For the United States of Venezuela, one gunboat; for the United States of Colombia, three gunboats, iron hulls.

The CHAIRMAN. Are you enlarging your plant?

Mr. GIBBONS. We regard it as ample.

The CHAIRMAN. What are the comparative advantages and disadvantages of the two systems of forging—steam-hammer and hydraulic press?

Mr. GIBBONS. No forging, large or small, can be made of uniform molecular consistence throughout under the hammer, and particularly does this relate to large masses. Any system of formation by pressure is not subject to this objection, and when it is considered that the maximum ability to endure strain is reached when uniform molecular consistence is had, manifestly the forging shaped under pressure is stronger and more able to resist any class of strain than is a hammered one.

The CHAIRMAN. Have you any tools and implements for the manufacture of guns similar to those cited in the portion of the Gun Foundry Board's report annexed to this circular?

Mr. GIBBONS. None. We could manufacture them in six months, but at what cost I cannot say without a careful estimate.

The CHAIRMAN. How can the Government best build ships, engines, and boilers?

Mr. GIBBONS. The Government can get its ships and engines equally well by building in Government yards—which would need more modern machinery than any of them possess to-day, and with the political element altogether eliminated, so that the management could gather around

it only those who possess skill in the business—or by contracting with fully responsible and skilled private builders.

The CHAIRMAN. Give an opinion of the comparative cost of these methods.

Mr. GIBBONS. Because of the difficulty that the management of a Government yard would have in eliminating political interference, because of the forcing upon it of political favorites who would draw salaries for ostensible services of no real value, and further because the eight-hour system obtaining there, the cost of the ships and machinery would thereby be much increased over those obtained by a system of private contract; but it does not follow from this that their excellence would in any respect be lessened.

The CHAIRMAN. Which are the best locations?

Mr. GIBBONS. Wherever material, labor, and fresh water obtain.

QUINTARD IRON WORKS.

STATEMENT OF N. F. PALMER, JR.

NEW YORK, *February* 5, 1885.

The CHAIRMAN. Please state your name and present position.

Mr. PALMER. N. F. Palmer, jr.; manager of the Quintard Iron Works.

The CHAIRMAN. Have you at any time been requested by the Government to build ships, engines, and boilers?

Mr. PALMER. Yes, and made proposals.

The CHAIRMAN. What is the capacity of your works to build engines and boilers?

Mr. PALMER. Capacity to undertake engines and boilers of any size the Government would require.

The CHAIRMAN. Please name the war vessels for which you have built any engines or boilers.

Mr. PALMER. Engines and boilers for the Alliance, boilers for the Alaska and Benicia, rebuilt the Montauk, and furnished new boilers; also boilers for the Spanish Government, and United States revenue steamer Mosswood.

The CHAIRMAN. Are you enlarging your plant?

Mr. PALMER. Not at present.

The CHAIRMAN. What experience have you had in the use of steam-hammers and hydraulic casting and forging presses?

Mr. PALMER. None with large steam-hammers, and none with hydraulic casting and forging presses.

The CHAIRMAN. How can the Government best build ships?

Mr. PALMER. In our opinion, they can be best supplied from private yards.

The CHAIRMAN. Give an opinion of the comparative cost of the methods—in private works or Government yards.

Mr. PALMER. It would be cheaper to build them in private yards.

The CHAIRMAN. Which are the best locations.

Mr. PALMER. The Delaware River at present.

CHARLES REEDER & SONS.

STATEMENT OF MR. CHARLES REEDER.

BALTIMORE, *November* 11, 1885.

The CHAIRMAN. Please state your name, residence, and present position in connection with the firm of Charles Reeder & Sons.

Mr. REEDER. Charles Reeder; Baltimore, Md.; I am not at present connected with the business, which is conducted by my sons, although it is carried on in the name of myself and sons.

The CHAIRMAN. What work do you turn out?

Mr. REEDER. Steam marine engines and boilers, principally.

The CHAIRMAN. Have you ever built any ships?

Mr. REEDER. No.

The CHAIRMAN. Have you built any engines or boilers for the Government?

Mr. REEDER. We have, for the Treasury Department and for the U. S. S. Pinola in 1861.

The CHAIRMAN. Where do you get the steel to build your boilers?

Mr. REEDER. From Coates & Co., of Baltimore.

The CHAIRMAN. Do they make it themselves?

Mr. REEDER. Yes, sir; they have a rolling mill in this city.

The CHAIRMAN. Have you at any time, since the close of the war, been requested by the Government to supply engines or boilers?

Mr. REEDER. Not for the Navy Department.

The CHAIRMAN. What is the capacity of your works to build them?

Mr. REEDER. I suppose we could build almost any size that the Government required. We have completed engines of 72-inch cylinders.

The CHAIRMAN. Have you any tools or implements suitable for the manufacture of guns?

Mr. REEDER. We have not.

The CHAIRMAN. Do you manufacture lathes or other tools?

Mr. REEDER. Not as a business. Our principal occupation is building and repairing marine engines and boilers.

The CHAIRMAN. What is your opinion as to the best method for the Government to adopt to get ships, engines, and boilers (whether to build them wholly in Government works or wholly in private works, or partly in Government works and partly in private works)?

Mr. REEDER. In my opinion, the Government ought to be constantly engaged in the construction of naval vessels in its own yards, and when necessary have others built in private yards. In Government yards it ought to be a constant operation—one ship after the other—in order to enable the Navy Department to keep up with the improvements of other nations. I think it is a mistake to order a large number of vessels at one time. They ought to be constructed continuously in order to make improvements. In my opinion, it is a great mistake to authorize the construction of a number of naval vessels and require the contracts all to be awarded to the lowest bidder. Instead of that the award of contracts ought to be limited or distributed among different builders. I think it better to build as experience points out, and to take pattern after superior vessels and improve on them. The only way that En-

gland and France ever brought their vessels to such perfection is by improving continually on what they had done before.

The CHAIRMAN. England and France build ships at the Government dock-yards and at the same time are having similar ships built at private yards. In that way there is constant comparison and constant improvement and development. Does not the Government, by this method, get the benefit of the improvement and development of its dock-yards at the same time that it is getting valuable information from the experience and improvements of the private builders?

Mr. REEDER. Yes, sir; that is so.

The CHAIRMAN. Do you then believe in building some of the ships entirely (engines, boilers, and all) in the navy-yards, and other ships entirely in private yards?

Mr. REEDER. I think there ought to be at all times one or more naval vessels under construction in Government yards; the sole direction ought to be with the Government departments. It is essential that those who direct should have some practical knowledge, or the means of acquiring experience, to enable them to determine in what direction improvement can be made.

The CHAIRMAN. What do you consider the comparative cost of ships built in navy-yards and in private yards?

Mr. REEDER. I cannot say as to the comparative cost, but it is generally more expensive to build ships in navy-yards than in private yards.

The CHAIRMAN. Which do you consider the best locations for private ship-building; that is as to the building of Government vessels?

Mr. REEDER. The location should be near the sea-board, as a matter of course. Near large cities would be the best places, I think.

The CHAIRMAN. Why do you consider locations near large cities the best?

Mr. REEDER. Experienced workmen can be more readily obtained; and, generally, the facilities for getting material are better.

The CHAIRMAN. Are you familiar with the general character of the heavy iron-clads that are being built in England now?

Mr. REEDER. Only from published descriptions.

The CHAIRMAN. From what you know of them, do you consider that we have everything in this country to build similar ships?

Mr. REEDER. I think we have. There is no doubt of it. It might require a little preparation, perhaps.

The CHAIRMAN. If those ships were to be, as some of them must be, armor-clad, where would you get the armor? They would require very heavy armor plates and very heavy steel shafting.

Mr. REEDER. The armor could be made at Pittsburgh. They have facilities there for making it, and we have plants here in Baltimore that could be easily extended so as to make it. No doubt the existing establishments here could arrange to make all that without any trouble.

The CHAIRMAN. Would those establishments require very large expenditures to make that preparation?

Mr. REEDER. I think not, except in enlarging some of their apparatus.

The CHAIRMAN. Will you give the names of some of those plants?

Mr. REEDER. The Abbott Company have extensive works in Baltimore that could be converted into a suitable place for manufacturing armor plates.

The CHAIRMAN. Can you recall the name of any firm in Pittsburgh that you think could make the steel armor plates? You know those plates are from 16 to 20 inches thick.

Mr. REEDER. I do not know the names of the firms engaged in the steel manufactures there. We have been getting our heavy forgings from William Miller in Pittsburgh.

The CHAIRMAN. Do you get steel ingots from him?

Mr. REEDER. We get our steel forgings from him. He, I am informed, gets his steel from Park Brothers.

The CHAIRMAN. What is the heaviest steel forging you have ever received from Pittsburgh, and to what use did you put it?

Mr. REEDER. It was 10 or 12 inches in diameter and was made into a crank shaft. We seldom make propeller shafts with solid couplings. It is almost impossible to make the neck (or section next to a large boss) of a heavy shaft perfectly solid. We usually make a plain shaft and shrink the couplings on.

The CHAIRMAN. You say you can make the engines and boilers for a ship of any size; are there any firms in Baltimore who have the capacity to build a modern armored ship for such engines and boilers?

Mr. REEDER. I suppose Woodhall & Co., Skinner, and Malster might do it. They have yards, and occasionally build vessels.

The CHAIRMAN. Has Woodhall built any iron or steel ships?

Mr. REEDER. He has built some small vessels. We could enter into the building of vessels very handily. We have a suitable place for it, and it only requires preparation.

The CHAIRMAN. Could those heavy armor plates be built as cheaply in the United States as in England?

Mr. REEDER. I am not prepared to say. I think the cost of labor is much less in England than it is here.

The CHAIRMAN. Where were the heavy tools in your yard made?

Mr. REEDER. Most of them we made ourselves. Our establishment has been in operation since 1815. The first marine engines constructed in this city were constructed by my father about seventy years ago.

The CHAIRMAN. Are there any foreign tools in your yard?

Mr. REEDER. We have one or two lathes that were made in England.

The CHAIRMAN. Have you any foreign mechanics in your yard?

Mr. REEDER. Yes; we always have.

The CHAIRMAN. Do you find them a necessity?

Mr. REEDER. Not a necessity; but there are always foreign mechanics here to be employed when we want them.

The CHAIRMAN. Would there be any necessity of employing foreign mechanics if you were to build a large armored ship?

Mr. REEDER. Not specially.

The CHAIRMAN. Have you any further suggestions to offer that will assist the committee in the direction of its inquiries?

Mr. REEDER. No further suggestions occur to me at present.

STATEMENT OF MR. JOHN ROACH.

NEW YORK, *January*, 1885.

Mr. MORGAN. Mr. Roach, in what business are you engaged?

Mr. ROACH. In the construction of ships, marine engines, and other iron and steel work. I have built some of the largest marine engines now afloat in the world, such as the engines of the Bristol, Providence, and Pilgrim, with 110-inch cylinder and 14-foot stroke of piston, the two former running successfully for fourteen years, the latter since her completion.

Mr. MORGAN. What steel or iron merchant ships have you built?

Mr. ROACH. In all, including those now being completed in my yard, ninety-one, seven of them of steel.

Mr. MORGAN. Of what material is the Puritan built?

Mr. ROACH. The shell of the ship is iron; the armor and turrets are to be steel.

Mr. MORGAN. What are her dimensions and what will be her displacement when the engines are on board?

Mr. ROACH. Her dimensions, &c., are as follows:

Length over all, 295 feet; breadth of beam, 60 feet; depth, 20 feet 6 inches; draught of water when launched, 6 feet 11 inches; draught with guns, armor, coal, and engines on board ready for commission, 18 feet.

Displacement when launched, 1,750 tons; displacement when down to her draught and in commission, 6,060 tons. Deducting the present weight of the ship without machinery, &c., 1,750 tons, there are left for armor, turrets, guns, machinery, coal, and other supplies, ready for commission, 4,310 gross tons.

With 500 tons of coal it is estimated that she will steam the following distances at the tabulated rates of speed, viz: With a speed of 14 knots, 1,545 nautical miles; of 12 knots, 2,266 nautical miles; of 10 knots, 3,331 nautical miles; of 9 knots, 4,316 nautical miles; of 7 knots, 6,477 nautical miles.

This gives a correct idea of the Puritan's fitness as a cruising monitor along our coast.

On 400 tons of coal it is estimated she can steam from Portland, Me., to New Orleans and return at the rate of 9 knots per hour, and, in case of an emergency, can make a speed of 338 nautical miles in twenty-four hours, or at a rate of 14 knots per hour. That is at a speed which is two knots faster than any other American man-of-war, and equal to the best of her class in the world. During recent trials her machinery proved a great success, and there is no doubt she will make 14 knots. She can carry 15-inch steel armor plate, with her guns, crew, and 400 tons of coal.

When on April 10, 1875, the Puritan was designed and contracted for, the armor then used on all similar vessels was made of iron, and was much lighter than that employed to-day. I saw the progress which was being made in Europe, and after the contract was signed I advised a change in the ship that enabled her to carry 40 per cent. more armor, gave her two knots more speed, permitted her to carry heavier guns, and yet increased her cost only about $25,000. Had this change not

been made, this ship, in view of the modern improvements in heavy armor and in guns, would to-day have been worthless. I did this work honestly, but up to the present I have not received a dollar for it, for the money even is not yet appropriated, although the certified bills are now in my possession.

As there are many reports about these ironclads, it may be well to explain here the Puritan's fitness for harbor defense:

First. There is no other armored vessel in the world to-day with the same thickness of armor and weight of guns which has so light a draught of water. European vessels of the same speed, weight of armor and guns draw much more water, and can enter only a few of our harbors at high tide, while the Puritan can enter most of our harbors at almost any state of the tide, either to coal or to retreat from a more powerful enemy; and in any emergency she could leave most of our ports at once without waiting for the tide. No foreign vessel of her power has these advantages.

Secondly. She has a double bottom, which, should the outside plating be broken, would by means of an inner skin and the eighty-four separate water-tight compartments still keep the vessel afloat. The advantages of the double-bottom system are shown in a late accident to the Pilgrim, which is built on this plan. Last year she ran on the rocks below Hell Gate, and tore a hole in her outer bottom about 40 feet in length, but the inner skin being intact she was saved, and brought her 400 passengers and a valuable cargo safely to wharf. She was put on the dry dock, repaired, and in two weeks was on her route again.

Thirdly. As the Puritan has a surface above the water line of but 2 feet 6 inches, her turrets alone are targets for an enemy's guns. This gives her a great advantage over other ships.

Fourthly. She is provided with a powerful ram.

A comparison of the Puritan with some of England's war ships of her class gives the following comparative values:

Comparison of defensive and offensive power of armored vessels for coast defense.

	Glatton, English.	Rupert, English.	Puritan, American.
Length.....feet..	245	250	280
Beam.....do..	54	53	60
Draught of water.....do..	19.5	23.7/12	18
Displacement.....tons..	4,910	5,440	6,060
Horse-power.....	2,870	4,630	3,760
Speed in knots.....	12.1	13.5	14.5
Side armor.....inches..	13½	12	14
Turrets.....do..	13½	12	16
Number of turrets.....	1	1	2
Number of guns.....	2 of 25 tons.	2 of 18 tons. 2 of 3½ tons.	4 of 40 tons.
Manner of loading.....	Muzzle.	Muzzle.	Breech.
Completed.....	1872.	1874.	.....

From this it is seen that while the English ship Glatton has only one turret and two 25-ton muzzle-loading guns, the Puritan has two turrets with 4 40-ton breech-loading guns, besides having a powerful ram, and a fighting capacity superior to either the Glatton or Rupert in weight and number of guns, in thickness of armor, and in speed.

Mr. MORGAN. What will be the weight of her guns and the thickness of her turrets?

Mr. ROACH. She will have four forty-ton breech-loading guns and the thickness of her turrets will be 16 inches.

Mr. MORGAN. Where were her shafts and engines built?

Mr. ROACH. In the yards of John Roach & Son, Chester, Pa.

Mr. MORGAN. Of what material are the shafts?

Mr. ROACH. The best American wrought iron.

Mr. MORGAN. Which do you prefer for the shafts of heavy ships, steel or wrought iron?

Mr. ROACH. The best American wrought iron.

Mr. MORGAN. Please state your reasons for the preference.

Mr. ROACH. There is a great uncertainty in the manufacture of steel shafts, owing to the facts that, as the ingots from which these are made are first cast in very large bodies and as the shrinkage of steel is much greater than that of iron or other metals, the outside edges of the ingot in the cooling process cool more rapidly than the interior; this causes them to shrink, the liquid metal by the natural contraction of cooling being drawn from the center, thus leaving it, as with all metals cast in heavy bodies in this way, porous and hollow. Then, when the ingot is heated, to be hammered into the shaft, these internal imperfections are not welded, for the shrinkage and the *bleeding holes* in and near the center are never welded, but are extended longitudinally and laterally, and formed into all shapes, as it is impossible to get a welding heat in the interior without burning up the outside metal. These imperfections are never discovered until the shafts break. In this connection I supply a list of two hundred and twenty-two ships the shafts of which were broken between January 1, 1881, and January 1, 1884, together with their nationalities, as certified to by the marine engineer of the Liverpool, Philadelphia, Boston, and New York underwriters. Of these ships 75 per cent. were British, and of the balance 30 per cent. were built in England, though sailed under the flags of other nations, while only two were American.

List of steamers which have broken their shafts from January 1, 1881, *to January* 1, 1884.

Nationality.	Name.	From—	To—	Date.
				1881.
British	Batavia	New York	Liverpool	Jan. 19
Italian	Coindant	Franchetti		Mar. 14
Do	Assiria	Singapore	Marseilles	Mar. 28
German	Metz	Neumuhlen	England	Mar. 29
French	Celeste	Workington	Barcelona	Apr. 3
Do	Senegal			Apr. 6
Dutch	Princess Amelie	Batavia	Amsterdam	Apr. 8
British	S. A. Sadler	Hamburg	London	Apr. 20
Do	Palmyra	Liverpool	New York	Apr. 22
Do	Jenny Otto	Shields	Madras	Apr. 24
Do	Queen	Whitstable	Arcachon	Apr. 26
Do	Cornelia	Algiers	Pomeron	Apr. 28
Do	Orchis	Galle	Liverpool	May 9
Do	Geo. Shattuck	St. Pierre, Miq.	Halifax	May 17
Do	Timor	Bombay	Hull	May 20
Do	Chas. Howard			May 24
German	Livonia	Riga	Lubeck	May 28
British	Bywell Castle	New York	Leith	
Spanish	Santiago	Porto Rico	Barcelona	
Swedish	Goteberg			June 4
Do	Forsog			
British	Victoria	London	New York	June 6
Do	Augustine	Para	London	June 23
German	Vandalia	Hamburg	New York	June 25
British	Donati	Buenos Ayres	England	June 25
Do	Canute	England	Constantinople	July 9
Norwegian	Meta	Christiansund	Lisbon	July 13
British	Royalist	Singapore	Labuan	July 13
Do	Pekin	do		July 19
Germany	Daschy Konig	Archangel		Aug. 1
British	Severn	Antilles	Havre	Aug. 9
Belgian	D. Steinmann	Antwerp	Boston	Aug. 12

List of steamers which have broken their shafts, &c.—Continued.

Nationality.	Name.	From—	To—	Date.
				1881.
British	Catalonia	Liverpool	New York	Aug. 13
Do.	Nantes	London	St. Nazaire	Aug. 28
Do.	Timsah*			Aug. 31
Do.	Alsatia	Halifax	New York	Sept. 1
Do.	Rochester	Boston	London	Sept. 1
Do.	Commander	New Orleans	Liverpool	Sept. 6
Do.	Flos	Grimsby	Galveston	Sept. 8
French	Ameriquet	Havre		Sept. 15
British	Egypt	Cardiff	Port Said	Sept. 27
Spanish	Aurrerra		Liverpool	Sept. 28
British	Berlin	Hamburg	Leith	Sept. 29
Do.	Westella	Cronstadt	Lynn	Sept. 30
Dutch	Koenig der Nederlanden†	Batavia	Amsterdam	Oct. 5
British	Sydney Hall	Bilboa	Swansea	Oct. 13
Do.	Lightning	Patras	Hamburg	Nov. 12
Do.	Faraday	London	New York	Nov. 16
Do.	Pelaw	Hamburg	Newcastle	Nov. 19
Do.	Bengal	Hong-Kong	Java	Nov. 23
Do.	Wyvern	Tagenrog	Rotterdam	Nov. 23
Do.	Cannel	London	Granton	Nov. 24
Do.	Dago	New York	London	Nov. 26
Do.	Tinto§			Nov. 26
Do.	Ben Lomond	Nicolaiff	Marseilles	
Do.	Pallion	Bombay	Antwerp	Dec. 1
Do.	Orion	Calcutta	London	Dec. 1
German	Allemanna	Hamburg	New York	Dec. 5
Belgian	Waealund	Antwerp	New York	Dec. 5
American	Tonawanda	Philadelphia	Providence	Dec. 5
British	Peer of the Realm	Calcutta	London	Dec. 11
Do.	Ayrshire	Mexico	New Orleans	Dec. 15
Norwegian	Dronning Sophie Stavanger			Dec. 19
British	Patagonia			
Spanish	Corunna	St. Juan	Cadiz	Dec. 24
				1882.
British	Rambler	Lagos	Gibraltar	Jan. 4
French	Ville de Malaga	St. Nazaire	Malaga	Jan. 4
British	Duke of Buccleuch			Jan. 12
Do.	Corea	Sydney	Thursday Isle	Jan. 12
Do.	Lotus	Bordeaux	Liverpool	Jan. 16
Do.	Mayfield	East London	Port Alfred	Jan. 26
American	Granada	Panama	San Francisco	Feb. 5
German	Adele	Konigsburg	Wismar	Feb. 7
British	Farnley Hall	Carthagena	Barrow	Feb. 12
Do.	Wiltshire	Bristol Ferry	Gibraltar	Feb. 12
Do.	Gamma	Cardiff	Odessa	Feb. 13
Do.	Menzaleh	Havre	Newport	Feb. 13
Do.	Tisza	Glasgow	Barcelona	Feb. 21
Austrian	Szapary	Glasgow	Venice	Feb. 22
British	Planet	Dantzic		Feb. 24
Do.	Jas. Malam	Alexandria	London	Mar. 4
Do.	City of Berlin	Liverpool	New York	Mar. 6
Do.	Italia	Swansea	Larne	Mar. 16
Do.	London Castle	London	Shanghai	Mar. 16
Do.	Thales	London	Buenos Ayres	Mar. 17
Do.	Deucalion	China	England	Mar. 25
Do.	Istrian	Boston	Liverpool	Mar. 26
Do.	Hope	Peterhead	Greenland	Apr. 10
Do.	Stowell	Newport	Naples	Apr. 12
Belgian	Pascal	Buenos Ayres	Antwerp	Apr. 24
British	Telemachus	Singapore	Amsterdam	Apr. 28
French	General Court			May 1
American	Norman	Philadelphia	Boston	May 1
British	Glenelg	Hong-Kong	Portland	May 8
Swedish	Atlas		Vestervik	May 11
British	Blackheath	Malta	Tagenrog	May 17
Do.	Border Chieftain	Newport	Venice	May 18
Do.	Catalonia	New York	Liverpool	May 20
Do.	Glengarry	Middlesboro	Hamburg	May 21
Belgian	Lippe	Bilboa	Antwerp	June 3
British	Sarpedon	London	Shanghai	June 5
American	Worcester	Halifax	Boston	June 12
British	Berlin	Leith	Cuxhaven	June 13
Do.	Scindia	Sulina	England	June 15
Danish	Thyra	Liban	Schiedam	June 17
British	Llandaff	Plymouth	Newport	June 19
Do.	Annie Ainsley	Porman	do	June 23

*Arrived at Gibraltar.
: Foundered, her shaft having broken in a gale.
† Found cracked while in dock.
§ Put into Lisbon.

List of steamers which have broken their shafts, &c.—Continued.

Nationality.	Name.	From—	To—	Date.
				1882.
Spanish	Gracia	Matanzas	St. John's	June 23
German	Helix	Riga		June 26
French	Desirade	Halifax	Montreal	
British	Sarah Ann	Carthagena		July 1
German	Tilsit	Memel	Swinemunde	July 3
British	Legos	Tagenrog	Gibraltar	July 11
Do	Idlewild	London	Cardiff	July 17
Do	Yorkshireman	Leghorn	Termini	July 24
Do	Bristol	Avonmouth	New York	July 31
Do	Columba	Licata	Cronstadt	Aug. 7
Do	Egbert	Calcutta	Bombay	Aug. 11
Swedish	Vale	Amsterdam	Stockholm	Aug. 11
French	Portena	Havre	Montevideo	Aug. 20
Italian	Rio Plata	Montevideo	Marseilles	Aug. 20
British	Algitha	New Orleans	Antwerp	Sept. 12
Do	Chilka	Suez	Bombay	Sept. 19
German	Vorsetzen	Manilla		Sept. 26
Italian	Commandant Franchetti	Sunderland	Bordeaux	Oct. —
British	City of Rochester			Oct. 2
Do	Carfin	Glasgow	Bilbao	Oct. 3
Do	Vandyck	Liverpool	Montevideo	Oct. 12
Do	Quito	Hull	Riga	Nov. 11
Do	Glenwilliam	Swansea	Belfast	Nov. 13
Do	Glamorgan	Liverpool	Boston	Nov. 14
Spanish	Catalan	New Orleans	Liverpool	Nov. 17
British	Birling	Goole	Trouville	Nov. 19
French	Blidah	Marseilles	Cannes	Nov. 19
British	Devonia	Glasgow	New York	Nov. 24
Norwegian	Carlotta	Vigsnaes	Dunkirk	
British	Jane Cory	Dieppe	Hartlepool	Dec. 7
Do	Lucinda	Kurrachee	England	Dec. 8
Do	George Shattuck	St. Pierre	Halifax	Dec. 17
Do	Miaca	Newcastle	Terneuzen	Dec. 28
Do	Sapphire	Liban	Leith	Dec. 31
				1883.
French	Argo	Nossi-Be	Reunion	Jan. 6
British	Neptune	Galway	Glasgow	Jan. 13
Do	Dago	London	Bombay	Jan. 27
Do	Plato	Liverpool	Rio de Janeiro	Jan. 27
Do	Toronto	London	Sunderland	Feb. 3
Do	Habana	Liverpool	Manila	Feb. 4
Do	Coanwood	Genoa	Carthagena	Feb. 11
Austrian	Helios	Hong-Kong	Singapore	Feb. 13
German	Uranus	Huelva	Hamburg	Mar. 1
British	Lisboneuse	Ceara	Liverpool	Mar. 8
Do	Gardenia	Shields	New York	Mar. 9
Do	City of Chester	New York	Liverpool	Mar. 12
Do	Princess Alice	Liverpool	Iverness	Mar. 23
Spanish	Villa Real	Valencia	Cette	Mar. 29
French	Auguste Conseil	Huelva	Bordeaux	Apr. 3
German	Rio	Hamburg	Buenos Ayres	Apr. 4
Dutch	Burgemeister den Teu	Amsterdam	Batavia	Apr. 5
British	Mauritania	Liverpool	Stockholm	Apr. 14
Do	Scotia	Catania	Boston	Apr. 16
Do	Prince Arthur	Llandudno	Liverpool	Apr. 17
Do	Long Ditton	London	Cardiff	Apr. 22
French	Dom Pedro	Buenos Ayres	Havre	Apr. 23
British	Mabel	Tagenrog	England	Apr. 27
Norwegian	Wergeland	Valencia	Hull	Apr. 27
French	St. Augustine*			
Spanish	Francoli	Valencia	Liverpool	May 1
French	Vasconia	Buenos Ayres	Bordeaux	May 1
American	Empire	San Francisco	Pt. Townsend	May 3
British	Basil	Hamburg	Antwerp	May 4
German	Habsburg	New York	Bremen	May 6
British	Harefield		Riga	May 12
Do	Romeo	Ghent	Goole	May 20
Do	Lady Havelock	Cardiff	Bordeaux	May 21
Dutch	Voorwaarts	Amsterdam	do	May 24
Norwegian	Elgin	Grimsby	Christiania	May 26
British	Harrox	London	Buenos Ayres	May 29
Do	Palmerin	Montreal	Glace Bay	June 5
French	Martinique	Tunis		June 5
Spanish	Humaçoa	Liverpool	Santander	June 7
German	Thuringia	Vera Cruz	Hamburg	June 10
British	Zingari	Tönning	Newcastle	June 13
Do	Benefactor	Jamaica	London	June 14
Do	Ashbrooke	New Orleans	Bayonne	June 15
Do	Jas. Malam	Cardiff	Cronstadt	June 25
Do	Laxham	Newport	Naples	June 27

* Put into Carthagena.

Nationality.	Name.	From—	To—	Date.
				1883.
American	America	Baracoa	New York	July —
British	Camellia	Baltimore	Londonderry	July 6
Swedish	Ganthoid	Lubeck		July 6
British	Rowen	Cronstadt	Haparanda	July 12
Do	Denia	Liban	London	July 30
Do	Annandale	Port Said		Aug. 10
Do	Nantes	Varna	London	Aug. 16
Do	Zadne	Naples	Liverpool	Sept. 6
American	City of New York	Australia	San Francisco	Sept. 7
German	Lessing	New York	Hamburg	Sept. 8
British	Historian	Liverpool	New Orleans	Sept. 11
Do	Scandinavia	Gibraltar	Spezzia	Sept. 16
Do	Lymington	Lymington	Sunderland	Sept. 26
German	Lotto	Antwerp	Stettin	Sept. 27
British	Helmstedt	Cardiff	Odessa	Sept. 28
Do	Sarpedon	Liverpool	Penang	Oct. 1
Do	Czar	Hull	Bordeaux	Oct. 4
Do	Chester	Newcastle	Stockholm	Oct. 6
Do	Canada	London	New York	Oct. 7
Do	Imbro	Cronstadt	Sunderland	Oct. 8
Do	Princess of Wales	Harwick	Antwerp	Oct. 14
Do	Gov. Blackhall	Brisbane	Cooktown	Oct. 16
Do	Sirius			Oct. 16
Do	Lady Eglinton	Dublin	London	Oct. 18
Do	Streonshalk	Sulina	Gibraltar	Oct. 18
German	Ibis	Valparaiso	Havre	Oct. 21
Spanish	Asturiano	Liverpool	Havana	Oct. 26
British	Lady Lycett	Swansea	Alexandria	Nov. 7
Do	Alliance	Kingstown		Nov. 9
Do	Grantully	Nicolaiff	Alloa	Nov. 11
Do	Regina	Aarhuus	Riga	Nov. 19
Danish	Elf	Rowen	Cardiff	Nov. 24
French	Pelho	China	Marseilles	Dec. 16
British	Celtic	New York	Liverpool	Dec. 22
Do	Shotton	Newport	Kustendji	Dec. 24
Do	France	London	New York	Dec. 26

Mr. MORGAN. Do you know anything about the Miantonomoh, Terror, Amphitrite, and that class of monitors, now unfinished?

Mr. ROACH. Yes. I built the Miantonomoh, and the other three are similar to her.

Mr. MORGAN. What is their estimated speed?

Mr. ROACH. About 12 knots.

Mr. MORGAN. What thickness of armor can they carry?

Mr. ROACH. Eight inches.

Mr. MORGAN. Then they have less speed and lighter armor than the Puritan?

Mr. ROACH. They have.

Mr. MORGAN. Who built the Dolphin?

Mr. ROACH. John Roach & Son.

Mr. MORGAN. For what speed was she constructed?

Mr. ROACH. Fourteen knots (nautical miles).

Mr. MORGAN. What speed did she make on trial?

Mr. ROACH. An average speed of 16.4 nautical miles; that is about 19 statute miles per hour.

Mr. MORGAN. What caused the breaking of her shaft.

Mr. ROACH. A defect in the center of the ingot of the character already described; also what I believe to have been a great mistake, the forging of the coupling with the shaft, which, in my opinion, should never have been done.

Mr. MORGAN. What was her behavior at sea?

Mr. ROACH. Excellent.

Mr. MORGAN. What did you think of her qualities as a dispatch boat?

Mr. ROACH. As to speed and to capacity for standing heavy weather, excellent.

Mr. MORGAN. At what point in the shaft did the rupture occur?

Mr. ROACH. At the neck, or where the shaft is connected with the coupling.

Mr. MORGAN. Was any other injury done to the ship by this breaking of the shaft?

Mr. ROACH. None whatever.

Mr. MORGAN. Where, and by whom was the shaft of the Dolphin made?

Mr. ROACH. In Nashua, N. H., and by the Nashua Iron and Steel Company. It was made of steel, solid, and 13 inches in diameter. It was cast in the solid ingot, then hammered.

Mr. MORGAN. What was the capacity of the hammer used in making the shaft?

Mr. ROACH. It was a hammer of 12 ton tup, 32 inches diameter of cylinder, with 8.5-feet stroke, and worked at 80 pounds steam pressure. It is a great mistake to suppose that hammers must be enormously heavy to make perfect shafts. The welding of any metal is done by comparatively light blows. Heavy hammers are used, generally, to save labor and to reduce to the proper size by the least number of heats. It is impossible by the heaviest outside hammering to weld defects in the centre of a cast ingot, because sufficient welding heat can never be generated in the center. In regard to heavy hammers I have made shafts heavier and of larger diameter than any one else in this country or in England.* For example, the Pilgrim's shafts are 28 inches in diameter, and weigh 94,000 pounds, and they have never caused any trouble; and many others, nearly as large, have been made with the hammers at my works.

Mr. MORGAN. By whom and in what manner was the Dolphin's shaft tested before it was put into the ship?

Mr. ROACH. By a thoroughly competent officer of the Government; but it was impossible for him or any one to discover a defect in the center of the cast ingot, as he could judge only from the surface, which was perfect. The shaft came into my possession duly certified as being properly inspected.

Mr. MORGAN. Who made the other parts of the engine of the Dolphin?

Mr. ROACH. All the other parts of her engine were made by John Roach & Son.

Mr. MORGAN. Was any other part of the engine broken when the shaft gave way?

Mr. ROACH. None whatever.

Mr. MORGAN. If any other parts of the engine had been defective, would they probably have given way when the shaft broke?

Mr. ROACH. They certainly would, as they were put to a greater test than they ever will be again. From the time the shaft broke until the engine was stopped, not only were all the broken connections grinding against each other, but the ship was running full speed and making over two knots an hour more than was expected. While thus running at full speed, orders were given by a Government officer to put the helm *hard down* in order to turn the ship about, thus bringing a strain upon the propeller and shaft 15 per cent. greater than would ever be required when running a straight course under full power. This is proper, as it

* See page 23.

is important to have a war ship maneuver and turn quickly, either to retreat or to attack an enemy. In a merchant ship the engine is slowed down when turning, and the strain is consequently reduced. All war steamers should be provided with extra strong shafts for such emergencies.

Mr. MORGAN. Who is building the engines of the Atlanta, Chicago, and Boston?

Mr. ROACH. John Roach & Son.

Mr. MORGAN. Of what material will the shafts be made?

Mr. ROACH. Steel.

Mr. MORGAN. From what place or places were the ores brought, from which the steel for these three ships was made?

Mr. ROACH. Principally from Lake Champlain, Virginia, New Jersey, and North Carolina.

Mr. MORGAN. Who made the steel and rolled the plates of the hulls of these ships?

Mr. ROACH. Principally John Roach & Son.

Mr. MORGAN Please give a list of the various iron and steel ships, with their tonnage and the horse-power of their engines, which have been built at your yards at Chester since you began such work.

Mr. ROACH. The following is a list:

Iron and steel vessels built by John Roach & Son at Chester, Pa., from 1871 to 1884.

[Legend: P., propeller; S. W., side-wheel; T. S., twin-screw; H. P., horse-power.]

Type.	Name of vessel.	Length over all.	Beam.	Depth.	Gross tonnage.
		Ft. in.	Ft. in.	Ft. in.	
P.	City of Peking	419 0	47 4	37 3	5,079.25
P.	City of Tokio	419 0	47 4	37 3	5,079.25
	Chicago	341 6	48 0	34 5½	4,500.00
	City of Rio de Janeiro	368 6	38 5	30 3	3,548.30
	City of Para	368 6	38 5	30 3	3,532.25
	Atlanta	286 0	42 0	25 8½	3,500.00
	Boston	286 0	42 0	25 8½	3,500.00
S. W.	Pilgrim	336 6	50 0	17 6	3,483.68
P.	City of New York	352 0	40 0	30 5	3,019.56
P.	City of Sydney	352 0	40 0	30 5	3,016.46
P.	City of San Francisco	352 0	40 0	30 5	3,009.25
P.	Lampasas	349 4	40 3	28 2	2,942.85
P.	Alamo	349 4	40 3	28 2	2,942.85
P.	Colima	312 0	40 0	30 6	2,905.64
T. S.	United States monitor Puritan	295 9	60 0	17 0	2,898.00
P.	City of Augusta	320 9	40 6	26 5	2,870.60
P.	Louisiana	349 9	39 0	27 8	2,940.33
P.	Guadalupe	338 10	39 2	28 2	2,839.29
P.	San Marcos	338 10	39 2	28 2	2,839.29
P.	Colorado	329 1	39 2	28 1	2,765.00
P.	Seneca	296 7	42 1	27 3	2,750.00
P.	Newport	346 0	38 7	25 0	2,735.00
P.	Columbia	332 0	38 4	25 1	2,722.00
P.	Colon	300 0	40 0	30 6	2,714.00
P.	Nacoochee	310 7	40 9	25 11	2,680.00
P.	Tallahassee	310 7	40 9	25 11	2,677.41
P.	Chattahoochee	310 7	40 9	25 11	2,676.35
P.	Advance	315 2	38 4	24 7	2,604.57
P.	Reliance	315 2	38 4	24 7	2,604.05
P.	Finance	315 2	38 4	24 7	2,603.08
P.	City of Washington	320 0	38 0	29 3	2,618.21
P.	Rio Grande	308 0	39 0	22 10	2,566.48
P.	City of Alexandria	336 6	38 6	26 4	2,490.22
P.	Saratoga No. 2	318 6	38 1	24 0	2,426.13
P.	Santa Rosa	346 0	40 8	23 2	2,416.78
P.	Santiago	290 9	38 11	23 7	2,358.78
P.	Guyandotte	286 11	40 6	27 1	2,354.56
P.	Roanoke	286 11	40 6	27 1	2,350.57
P.	Oregon	300 0	38 1	24 10	2,335.26
P.	Cienfuegos	311 3	39 7	23 5	2,332.09
P.	Niagara	292 0	38 1	24 10	2,285.23
P.	Saratoga No. 1	292 0	38 1	24 10	2,285.65

Iron and steel vessels built by John Roach & Son at Chester, Pa., from 1871 to 1884—Cont'd.

Type.	Name of vessel.	Length over all.	Beam.	Depth.	Gross tonnage.
P.	Willamette	336 10	39 2	23 2	2,269.00
P.	City of Columbus	272 0	38 6	25 11	2,250.00
P.	Umatilla	329 11	40 6	23 9	2,131.49
P.	Walla-Walla	329 11	40 6	23 9	2,124.80
P.	City of Macon	272 0	38 6	25 11	2,092.80
P.	San José	304 10	36 4	22 6	2,080.72
P.	San Juan	304 10	36 4	22 6	2,076.14
P.	San Blas	304 10	36 4	22 6	2,075.00
S. W.	Tillie E. Starbuck	273 0	42 3	25 4	2,033.00
P.	City of Savannah	272 0	38 6	25 11	2,029.40
T. S.	United States monitor Miantonomoh	262 8	55 0	16 6	2,025.75
P.	Gate City	272 0	38 6	25 11	1,997.00
S. W.	Alaskan	288 4	39 6	14 6	1,717.00
P.	George W. Elder	258 2	38 0	23 11	1,709.00
P.	San Antonio	282 8	36 0	22 0	1,605.00
P.	State of Texas	248 0	36 0	21 11	1,548.66
P.	Manhattan	246 9	35 3	21 11	1,525.19
P.	Dolphin	256 9½	31 10½	19 6½	1,500.00
P.	City of Panama	258 0	36 0	22 3	1,490.24
P.	City of Guatemala	258 0	36 0	22 3	1,487.30
P.	City of Waco	244 0	36 0	21 11	1,486.21
P.	City of Topeka	218 6	35 0	19 6	1,284.00
P.	United States sloop Alert	190 9	32 0	16 3	1,246.00
P.	United States sloop Huron	190 9	32 0	16 3	1,246.00
P.	Western Texas	239 7	34 0	17 5	1,121.12
P.	City of Chester	206 6	33 6	17 4	1,106.21
P.	Breakwater	221 0	30 0	21 2	1,044.39
P.	Perkiomen	219 5	37 0	18 9	1,035.35
S. W.	Sirius	240 6	32 6	11 7	993.31
	Erie	192 0	36 0	15 6	981.00
P.	City of Palatka	215 3	34 2	12 11	882.77
S. W.	Cepheus	223 3	32 6	11 6	882.08
S. W.	Cygnus	223 3	32 6	11 6	857.44
	Newberne	162 9	24 3	9 3	846.00
	Garden City	194 10	33 6	14 9	825.55
	Berks	196 6	28 6	15 7	553.09
P.	Yosemite	197 6	28 11	13 4	481.51
	Amazonia	206 2	32 6	10 11	457.20
	Juan Mir	165 0	28 2	13 2	422.57
	Elias	173 4	27 3	8 7	299.80
	Utowana	135 0	20 6	12 2	141.38
P.	Viking	135 0	20 6	12 2	141.38
	Ancon	98 3	18 1	6 11	105.30
	Gracious	100 10	14 0	5 8	72.00
	George E. Weed	78 0	16 9	8 6	30.49
	Pacific Mail coal barge	82 10	20 6	6 7	142.00
	Pacific Mail coal barge	82 10	20 6	6 7	142.00
	Pacific Mail water barge	69 9	18 0	6 7	94.00
	Total tonnage				179,870.89

The engines for these ships develop 225,500 horse-power.

In building these 91 ships there was made for them about 360 shafts. I have also made many shafts for other builders, and have also replaced shafts in foreign ships which have come into the port of New York with broken ones, and not one of these has broken, except in one instance when a crank pin cracked. These shafts were made of the best American wrought iron and by the best workmen, and their success convinces me that there is very little improvement to be made in my works in the construction of shafts. There is no similar record as to shafts in the world.

Mr. MORGAN. How have those ships answered the lines of service for which they were designed?

Mr. ROACH. With the exception of four, they are all still afloat. One was burned and three ran ashore; but the best answer I can give as to their service, &c., is the following:

I have built 23 ships for the Pacific Mail Steamship Company and the Brasil Steamship Company, with a tonnage of 63,000 tons, and have built for the coast trade, for C. H. Mallory & Co., 12 ships, with a tonnage of 28,000; for the Ocean Steamship

Company, 6 ships, with a tonnage of 16,000; for Old Dominion Company, 7 ships, with a tonnage of 15,250.

These vessels were built for us by Mr. Roach, all of them having compound engines, and they have given us entire satisfaction.

J. B. HOUSTON, Pres't P. M. S. S. Co.
JAS. E. WARD & CO.
S. W. ROWELL, Secretary U. S. & B. M. S. S. Co.
C. H. MALLORY & CO.
A. L. McCREADY, Pres't Old Dominion Co.
Capt. P. C. LEFEVRE, Sup't Ocean S. S. Co.

Mr. MORGAN. If the proper material were provided for armored steel ships, such as the first-class ships in the British navy, could they be built complete with their engines and all equipments, except guns, in your ship yards?

Mr. ROACH. Yes, sir. I have all the appliances; the steel plant and all the blast furnaces and equipments necessary to make from our own American ores, lacking only the extra size rolls, steel armored plates equal to any in the world. Such facilities could be added to what I have at present for making steel plates equal to the best in the world at a cost of $350,000, which would be cheerfully spent if some permanent and decided policy were established to encourage this expenditure. Then war ships equal to any afloat, in speed and in weight of armor, could be turned out complete, except the guns.

Mr. MORGAN. If a proper plant were provided for this class of work, as indicated in the previous question, what would be the percentage of difference in the cost of building such ships complete at Chester, Pa., and on the Clyde?

Mr. ROACH. It is hard to tell what the difference in cost would be between the United States and Europe, for the necessities of the case regulate the price of this class of work abroad. If it became known that we were likely to need war ships in a hurry, and had not the facilities for their construction at home, the cost would probably be much more than what would allow a fair profit here. I would be willing to supplement my present facilities with the rolls and all other modern improvements, so as to make the heaviest steel plates and to turn out for our Government ships equal in speed and weight of armor to any in the world, building them entirely from our own mines and forests and with our own labor. I have all the plant except the rolls, and I have skilled labor which is equal to any in the world.

Mr. MORGAN. What are your facilities capable of producing?

Mr. ROACH. With this improvement, and no delays, caused by changes, I could turn out four ships a year. Though the machinery is the most tedious part, I have ample facilities in that department, and in the last eighteen months I have built more heavy engines than would be required for four war ships.

Some system which would give builders encouragement by warranting contracts at a fair, moderate compensation, say a profit of 10 per cent. (the cost of making the armor to be kept by the Government, and this 10 per cent. above cost to be paid, and the right to make all experiments on a regular profit to the builder of 10 per cent. over cost being also reserved by the Government), would be much more economical for the Government than for it to do this work itself.

The best illustration of the necessity for this course is afforded by the fact that, although we are now at peace with the world and not likely very soon to be involved in war, yet, when two years ago Congress appropriated money for the manufacture of 7-inch steel armor for the U. S. S. Miantonomoh, and it was advertised for in this country,

no one was found who had the facilities for making it. Consequently it was purchased in England at a cost much larger than it could have been made at home with a decent, living profit, had we had the facilities for rolling it. We have been waiting for the last fifteen months for the plating of this little ship; but as it is not done yet, you can imagine what our humiliation would be in an emergency.

Mr. MORGAN. Please state anything further that will throw light on the economy, or other advantage, of building war ships under contract or by the United States in its own ship-yards.

Mr. ROACH. The United States Government has no plant for building, and if it had, it could not do this as cheaply as outside responsible contractors. But I can best answer this question by citing England's policy with all her great navy-yards. I am indebted to the Office of Naval Intelligence, Navy Department, for the following valuable and carefully prepared table. In it will be found the percentage of the ships and engines built in private ship-yards, compared with those built in her Government dock-yards.

ARMORED SHIPS OF ENGLAND IN COMMISSION OR ABOUT TO GO INTO COMMISSION.

[All work done in private yards marked thus, *.]

Class.	Name.	Displacement.	Horse-power.	Draft.	Length.	Beam.	Where built.	Maker of engines.	Completed.	Cost.		Speed.
										Hull.	Engines.	
		Tons.		*Ft. In.*	*Ft. In.*	*Ft. In.*				£	£	*Knots.*
Barbette ship	Témeraire	8,540	7,529	27 2	285 0	62 9	Chatham	Humphreys*	1877	367,739	103,831	14.6
Do	Collingwood	9,150	7,000	26 3	325 0	68 0	Pembroke*	....do	1885	447,000	87,500	a16
Do	Imperieuse	7,390	8,000	25 5	315 0	62 0	Portsmouth	Maudslay*	1884	380,000	104,500	a16
Do	Warspite	7,390	8,000	25 5	315 0	62 0	Chatham	Penn*	1885	350,000	107,600	a16
Do	Rodney	9,600	9,500	27 3	325 0	68 0	.. do	Humphreys*	1885	455,000	102,000	a16
Do	Howe	9,600	9,500	27 3	325 0	68 0	Pembroke*	....do*	1885	440,000	103,000	a16
Turret ship	Scorpion	2,750	1,450	17 0	224 6	42 4	Birkenhead*	Laird*	1865	92,000	18,500	10.5
Do	Wivern	2,750	1,450	17 0	224 6	42 4	....do	....do	1865	98,000	18,300	10.5
Do	Prince Albert	3,880	2,130	20 4	240 0	48 0	Poplar*	Humphreys*	1866	178,000	24,000	11.2
Do	Monarch	8,320	7,840	26 7	330 0	57 0	Chatham	....do*	1869	279,900	74,600	14.9
Do	Cerberus	3,340	1,370	15 3	225 0	45 0	Jarrow*	Maudslay*	1870	99,300	18,000	9.5
Do	Magdala	3,340	1,440	15 3	225 0	45 0	Blackwall*	Ravenhill*	1870	115,400	17,000	10.4
Do	Abyssinia	2,900	950	14 6	225 0	42 0	Poplar*	Dudgeon*	1870	97,000	9,500	9.6
Do	Hotspur	4,010	3,060	21 10	235 0	50 0	Glasgow*	Napier*	1871	135,067	36,400	12.6
Do	Glatton	4,910	2,870	19 5	245 0	54 0	Chatham	Laird*	1872	180,133	30,300	12.1
Do	Gorgon	3,480	1,670	16 4	225 0	45 0	Jarrow*	Ravenhill*	1874	122,904	15,660	11
Do	Hydra	3,480	1,470	16 4	225 0	45 0	Glasgow*	Elder*	1876	124,400	16,900	10.9
Do	Hecate	3,480	1,750	16 4	225 0	45 0	Poplar*	Ravenhill*	1877	124,900	15,600	10.6
Do	Cyclops	3,480	1,660	16 4	225 0	45 0	Blackwall*	Elder*	1877	126,400	17,600	10.7
Do	Thunderer	9,330	6,270	27 0	285 0	62 8	Pembroke*	Humphreys*	1877	306,300	53,900	13.4
Do	Rupert	5,440	4,630	23 7	250 0	53 0	Chatham	Napier*	1874	192,000	39,300	13.6
Do	Neptune	9,310	8,000	26 1	300 0	63 0	Poplar*	Penn*	1881	d800,000	.....	14.2
Do	Dreadnaught	10,820	8,210	26 9	320 0	68 10	Pembroke*	Humphreys*	1879	498,000	116,227	14
Do	Inflexible	11,880	8,010	26 4	320 0	75 0	Portsmouth	Elder*	1881	619,800	146,400	13.8
Do	Agamemnon	8,510	6,300	24 0	280 0	66 0	Chatham	Penn*	1883	402,000	101,700	13
Do	Ajax	8,510	6,440	24 0	280 0	66 0	Pembroke*	....do	1883	411,620	106,700	13.5
Do	Conqueror	6,200	5,800	24 0	270 0	58 0	Chatham	Humphreys*	1883	286,500	69,000	15.5
Do	Edinburgh	9,150	6,807	26 3	325 0	68 0	Pembroke*	....do	1883	470,000	77,000	16
Do	Colossus	9,150	7,488	26 3	325 0	68 0	Portsmouth	Maudslay*	1884	468,700	93,400	16.53
[illegible]	Warrior	9,210	5,270	26 9	380 0	58 0	Blackwall*	Penn	1861	282,284	74,409	14
Do	Defence	6,270	2,540	26 7	280 0	54 2	Jarrow*	....do	1862	197,879	34,300	11.6
Do	Resistance	6,270	2,430	26 10	280 0	54 1	Poplar*	....do	1862	208,250	30,765	11.8
Do	Black Prince	9,210	5,770	26 10	380 0	58 4	Glasgow*	....do	1862	288,154	74,480	16.6
Do	Hector	6,710	3,200	26 0	280 0	56 5	....do	Napier*	1864	237,434	45,700	12.8
Do	Valiant	6,710	3,350	26 8	280 0	56 4	Poplar*	Maudslay*	1865	271,900	48,309	12.5
Do	Achilles	9,820	5,730	27 8	380 0	58 8	Chatham	Penn*	1864	375,400	69,117	14.3
Do	Minotaur	10,690	6,700	27 8	400 0	59 4	Blackwall*	....do	1867	377,300	79,500	14.4
Do	Agincourt	10,690	6,870	27 9	400 0	59 5	Birkenhead*	Maudslay*	1868	361,700	83,700	14.8
Do	Vixen	1,280	740	11 10	160 0	32 5	Deptford Green*	....do	1868	46,300	7,300	8.9

Do	Viper	1,230	740	11 8	160 0	32 0	Poplar*	...do	1867	43,500	7,600	9.5
Do	Bellerophon	7,550	6,500	26 7	300 0	56 1	Chatham	Penn*	1866	255,700	86,900	14.1
Do	Lord Warden	7,840	6,700	27 11	280 0	59 0	...do	Maudslay*	1867	247,000	68,500	13.5
Do	Northumberland	10,780	6,560	27 6	400 4	59 5	Millwall*	Penn*	1868	391,400	79,900	14.1
Do	Waterwitch	1,280	780	11 11	162 0	32 1	Blackwall*	Dudgeon*	1867	44,252	14,500	8.8
Do	Penelope	4,470	4,700	17 6	260 0	50 0	Pembroke*	Maudslay*	1868	145,900	40,800	12.7
Do	Hercules	8,680	6,750	26 6	325 0	59 0	Chatham	Penn*	1868	278,300	82,000	14.7
Do	Repulse	6,190	3,350	26 1	252 0	59 1	Woolwich	...do	1870	197,800	84,300	12.2
Do	Audacious	6,010	4,330	23 8	280 0	54 0	Glasgow*	Ravenhill*	1870	193,800	52,600	13.2
Do	Invincible	6,010	4,330	23 2	280 0	54 0	...do	Napier*	1870	187,055	52,385	13.8
Do	Swiftsure	6,910	4,910	26 1	280 0	55 0	Jarrow*	Maudslay*	1872	207,900	49,000	13.7
Do	Sultan	9,290	7,720	27 11	325 0	59 0	Chatham	Penn*	1871	281,500	76,000	14
Do	Triumph	6,640	5,110	26 7	280 0	55 0	Jarrow*	Maudslay*	1873	209,000	49,000	13.5
Do	Iron Duke	6,010	4,270	23 3	280 0	54 0	Pembroke*	Ravenhill*	1871	146,300	50,000	13.4
Do	Alexandra	9,490	8,610	26 6	325 0	63 8	Chatham	Humphreys*	1877	395,790	126,000	14
Do	Superb	9,170	6,580	26 5	332 0	59 0	Blackwall*	Maudslay*	1871	.....	d531,846	13.7
Do	Shannon	5,390	3,370	23 6	260 0	54 0	Pembroke*	Laird*	1877	233,900	53,300	12.3
Do	Nelson	7,630	6,640	26 6	280 0	60 0	Glasgow*	Elder*	1881	303,300	87,500	14
Do	Northampton	7,630	6,070	25 9	280 0	60 0	...do	Penn*	1878	296,800	98,900	13.1
Do	Belliale	4,870	3,290	21 1	245 0	52 0	Poplar*	Maudslay*	1878	d240,000	.....	12.2
Do	Orion	4,870	4,040	21 4	245 0	52 0	...do	...do	1882	239,270	52,900	12.8
Torpedo ram, protected but not heavily armored.	Polyphemus	2,640	5,500	20 6	240 0	40 0	Chatham	Humphreys*	1885	152,549	69,898	17

BUILDING.

Barbette ship	Benbow	10,000	9,500	26 9	330 0	68 6	Blackwall*		Building	460,000	104,000	16
Do	Camperdown	10,000	9,500	26 9	330 0	68 6	Portsmouth	Maudslay*	...do	460,000	104,000	16
Do	Anson	10,000	9,500	26 9	330 0	68 6	Pembroke*	.....	...do	.....	.....	
Turret ship	Hero	6,200	5,800	24 0	270 0	58 0	Chatham	.....	...do	e286,000	69,000	15
Turret vessels	Renown	10,470	8,500 to 10,000	27 3	340 0	70 0	Newcastle*	Maudslay*	...do	d601,000	.....	16.5
	Sanspareil	10,470	8,500 to 10,000	27 3	340 0	70 0	Blackwall*	...do	...do	d604,000	.....	16.5
Belted cruisers	Australia	5,000	7,500	22 6	300 0	56 0	Glasgow*	...do	...do	215,000	.....	18.5
	Galatea	5,000	7,500	22 6	300 0	56 0	...do	...do	...do	215,000	.....	18.5
	Orlando	5,000	7,500	22 6	300 0	56 0	Jarrow*	...do	...do	224,000	.....	18.5
	Undaunted	5,000	7,500	22 6	300 0	56 0	...do	...do	...do	224,000	.....	18.5
	Narcissus	5,000	7,500	22 6	300 0	56 0	Hull*	...do	...do	215,000	.....	18.5
Ram	Torpedo ram	3,220	5,500	19 9	270 0	46 0	Chatham	.....	...do	.....	.....	17.5

a Estimated. b Launched in September, 1884; will be ready in a year. c Launched April, 1885; to be fitted out as soon as possible. d Total cost. e About.

UNARMORED SHIPS OF ENGLAND ABOVE 900 TONS DISPLACEMENT.

[All work done in private yards marked thus, *.]

Name.	Displacement.	Horse-power.	Draft.	Length.	Beam.	Where built.	Maker of engines.	Completed.	Cost.		Speed.
									Hull.	Engines.	
	Tons.		*Ft. In.*	*Ft. In.*	*Ft. In.*				£	£	*Knots.*
Dryad	1,620	1,570	17 1	187 0	36 0	Devonport*	Napier*	1866	36,088	16,834	11.8
Eclipse	1,760	1,950	16 7	212 0	36 0	Sheerness	do	1867	36,242	24,000	12.9
Inconstant	5,780	7,360	25 6	337 0	50 3	Pembroke*	Penn*	1868	138,500	74,700	16.2
Briton	1,860	2,150	17 1	220 0	36 0	Sheerness	Rennie*	1869	36,299	21,300	13.1
Druid	1,860	2,270	16 5	220 0	36 0	Deptford*	Maudslay*	1869	33,700	22,100	12.9
Thetis	1,860	2,270	17 0	220 0	36 0	Devonport*	Rennie*	1871	43,900	21,100	13.3
Dido	1,760	2,520	16 4	212 0	36 0	Portsmouth	Humphreys*	1869	36,400	19,500	13.5
Tenedos	1,760	2,030	16 10	212 0	36 0	Devonport*	Elder*	1870	36,200	20,121	12.8
Volage	3,080	4,530	21 5	270 0	42 0	Blackwall*	Penn*	1869	84,975	41,378	15
Active	3,080	4,130	21 4	270 0	42 0	do	Humphreys*	1869	85,795	40,361	15
Shah	6,250	7,480	26 8	334 8	52 0	Portsmouth	Ravenhill*	1873	177,912	57,333	16.2
Modeste	1,970	2,180	17 10	220 0	37 0	Devonport*	Napier*	1873	49,518	22,094	12.7
Encounter	1,970	2,130	17 6	220 0	37 0	Sheerness	Rennie*	1873	43,271	19,527	13
Amethyst	1,970	2,140	18 4	220 0	37 0	Devonport*	do	1873	49,129	20,417	13.2
Diamond	1,970	2,140	18 0	220 0	37 0	Sheerness	Hawthorn*	1874	50,600	26,189	12.5
Sapphire	1,970	2,360	18 1	220 0	37 0	Devonport*	do	1874	51,986	26,311	13.5
Egeria	940	1,010	14 3	160 0	31 4	Pembroke*	Humphreys*	1873	32,436	10,414	11.3
Sappho	940	880	13 11	160 0	31 4	Blackwall*	do	1873	29,749	9,242	10.5
Flying Fish	940	840	14 4	160 0	31 4	Chatham	do	1873	29,444	10,000	10.9
Fantome	940	970	14 2	160 0	31 4	Pembroke*	do	1873	30,343	10,197	11
Albatross	940	840	14 5	160 0	31 4	Chatham	do	1873	28,729	9,697	10.5
Daring	940	920	14 7	160 0	31 4	Blackwall*	Penn*	1874	30,023	9,590	10.6
Raleigh	5,200	5,640	24 7	298 0	49 0	Chatham	Humphreys*	1873	147,248	46,138	15.3
Rover	3,460	4,960	23 0	280 0	43 6	Blackwall*	Ravenhill*	1874	104,718	65,021	14.5
Boadicea	4,140	5,130	23 8	280 0	45 0	Portsmouth	Rennie*	1875	153,167	70,400	14.7
Bacchante	4,130	5,420	23 9	280 0	45 7	Chatham	Eastons	1877	152,454	76,954	15
Opal	2,120	2,190	18 7	220 0	40 0	Doxfords*	Napier*	1875	68,574	27,375	13.3
Tourmaline	2,120	1,970	18 8	220 0	40 0	Dixon & Co*	Hawthorn*	1875	69,998	25,771	12.6
Turquoise	2,120	1,990	19 1	220 0	40 0	Earle's, Hull*	Earle's Hull*	1876	70,468	27,458	12.3
Emerald	2,120	2,170	19 0	220 0	40 0	Pembroke*	Thompson*	1876	72,312	26,130	13.2
Garnet	2,120	2,000	19 7	220 0	40 0	Chatham	Hawthorn*	1877	65,683	27,779	13
Osprey	1,130	1,010	15 11	170 0	36 0	Sheerness	Humphreys*	1876	39,664	11,674	11.6
Wild Swan	1,130	800	15 10	170 0	36 0	Glasgow*	Hawthorn*	1876	39,643	11,833	10.3
Penguin	1,130	720	16 1	170 0	36 0	do	do	1876	39,611	11,879	10
Pelican	1,130	1,060	15 3	170 0	36 0	Devonport*	Humphreys*	1877	41,282	14,939	11.6
Cormorant	1,130	950	15 0	170 0	36 0	Chatham	do	1877	37,630	11,587	11.3
Gannet	1,130	1,110	15 10	170 0	36 0	Sheerness	do	1878	39,581	12,889	11.5
Dragon	1,130	1,010	15 6	170 0	36 0	Devonport*	Maudslay*	1878	36,427	13,069	11.5
Pegasus	1,130	970	15 9	170 0	36 0	do	Laird*	1878	36,607	12,800	11.4
Kingfisher	1,130	1,000	16 4	170 0	36 0	Sheerness	Maudslay*	1879	36,915	12,244	11.6
Merando	1,130	1,020	16 5	170 0	36 0	Devonport*	Napier*	1879	36,366	12,290	11.5

Mutine	1,130	1,120	16 5	170 0	36 0	....do	Maudslay*	1880	35,891	12,189	12
Espiègle	1,130	1,140	15 9	170 0	36 0	....do	....do	1880	36,577	12,273	11.5
Euryalus	4,140	5,110	23 3	280 0	45 6	Chatham	Eastons*	1877	132,254	76,959	14.7
Iris	3,730	7,330	22 1	300 0	46 0	Pembroke*	Maudslay*	1877	112,310	102,318	18.5
Mercury	3,730	7,290	22 0	300 0	46 0	....do	....do	1878	122,477	102,740	18.6
Comus	2,380	2,450	19 3	225 0	44 6	Glasgow*	Elder*	1878	84,498	29,477	12.9
Champion	2,380	2,340	19 2	225 0	44 6	....do	....do	1878	84,219	29,696	13
Carysfort	2,380	2,400	19 0	225 0	44 6	Elder*	....do	1878	84,653	29,948	12.96
Cleopatra	2,380	2,610	19 3	225 0	44 6	Glasgow*	Humphreys*	1878	86,451	27,871	13
Curaçoa	2,380	2,540	18 10	225 0	44 6	Elder*	....do	1878	85,942	27,125	13
Conquest	2,380	2,670	18 6	225 0	44 6	....do	....do	1878	86,691	28,089	13
Constance	2,380	2,590	19 2	225 0	44 6	Chatham	Penn*	1880	77,300	36,030	13.7
Canada	2,380	2,430	19 1	225 0	44 6	Portsmouth	Rennie*	1881	91,064	31,101	13
Cordelia	2,380	2,420	19 1	225 0	44 6	....do	....do	1881	81,308	30,536	13
Satellite	1,420	1,110	15 9	200 0	38 0	Sheerness	Humphreys*	1881	47,318	15,407	13
Heroine	1,420	1,130	15 9	200 0	38 0	Devonport*	....do	1881	52,451	14,438	13.1
Hyacinth	1,420	1,190	15 9	200 0	38 0	....do	....do	1881	53,425	14,517	13.1
Caroline	1,420	1,500	15 9	200 0	38 0	Sheerness	Maudslay*	1882	45,355	13,114	13
Rapid	1,420	1,500	15 9	200 0	38 0	Devonport*	....do	1883	46,992	13,285	13
Royalist	1,420	1,500	15 9	200 0	38 0	....do	....do	1883	47,128	13,381	13
Sphinx	1,130	1,140	10 3	200 0	32 0	Blackwall*	Penn*	1884	.....	.....	12
Leander	3,750	5,000	20 6	300 0	46 0	Glasgow*	Napier*	1882	87,843	60,610	17
Arethusa	3,750	5,000	20 6	300 0	46 0	....do	....do	1882	86,763	58,435	17
Phaeton	3,750	5,000	20 6	300 0	46 0	....do	....do	1883	86,763	58,435	17
Amphion	3,750	5,000	20 6	300 0	46 0	Pembroke*	Maudslay*	1883	108,780	65,500	17
Dolphin	925	870	14 0	157 0	32 0	Dixon & Co*	Hawthorn*	1882	25,850	9,800	11.3
Wanderer	925	870	14 0	157 0	32 0	....do	....do	1883	25,850	9,800	11.3
Calypso	2,770	3,000	19 11	235 0	44 6	Chatham	Rennie*	1883	98,100	38,000	13.8
Calliope	2,770	3,000	19 11	235 0	44 6	Portsmouth	....do	1884	90,620	38,000	13.8
Pylades	1,420	1,500	15 9	200 0	38 0	Sheerness	Laird*	1884	52,020	16,500	13.5
Acorn	970	850	14 3	167 0	32 0	Pembroke*	Maudslay*	1884	27,500	14,500	11
Mariner	970	850	14 3	167 0	32 0	Devonport*	Hawthorn*	1884	37,000	11,750	11
Reindeer	970	850	14 3	167 0	32 0	....do	....do	1884	35,000	11,750	11
Racer	970	850	14 3	167 0	32 0	....do	....do	1884	36,800	11,750	11
Ruby	2,120	1,830	18 8	220 0	40 0	Earle's Hull*	Earle's Hull*	1876	66,113	27,003	13
Melita	970	850	14 3	167 0	32 0	Malta	Malta*	Building	30,000	.....	11
Icarus	990	1,200	14 4	167 0	32 0	Devonport*	Jarrow & Co*	....do	36,800	12,725	12.5
Mersey	3,550	6,000	20 0	300 0	46 0	Chatham	Humphreys*	....do	106,500	54,000	17
Severn	3,550	6,000	20 0	300 0	46 0	....do	....do	....do	106,500	54,000	17
Thames	3,550	6,000	20 0	300 0	46 0	Pembroke*	Penn*	....do	100,000	53,500	17
Forth	3,550	6,000	20 0	300 0	46 0	....do	Hawthorn*	....do	100,000	48,500	17
Scout	1,430	3,200	14 6	220 0	34 0	Glasgow*	Thompson*	....do	43,000	23,600	16
Fearless	1,430	3,200	14 6	220 0	34 0	Barrow & Co*	Barrow & Co*	....do	40,250	23,250	16
Curlew	785	1,200	11 0	195 0	28 0	Devonport*	Penn*	....do	28,500	12,600	14
Landrail	785	1,200	11 0	195 0	28 0	....do	....do	....do	28,500	12,600	14
Seven additional, cout class	1,600	3,500	14 6	225 0	36 0	Glasgow*	Thompson*	....do	(a)	(a)	
Swallow	1,040	1,500	12 0	195 0	28 0	Sheerness	Rennie*	....do	33,000	13,000	13.5
Juno b	2,240	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
72 gunboats from 400 to 900 tons	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

a Not known.

b Sister ship to Ruby. Requiring extensive repairs.

BUILDING.

Seven torpedo cruisers, same class as "Scout."
One gun-vessel, same class as "Swallow."
Four gun-boats of about 600 tons displacement.
Also 32 more ships built in the dock-yards, and 7 built in the private yards.
Vessels about to be laid down for the British navy, January, 1885: Four iron-clads of the first-class; 2 torpedo rams of 3,000 tons; 5 belted cruisers of 5,000 tons; 7 scouts, from 1,400 to 1,500 tons; 30 torpedo boats of the first-class. Total, 51.
Besides this fleet, $32,000,000 has been appropriated to build 50 vessels to be finished in the next three years, making a total of 160 modern war vessels built since the close of our last war. Nearly all are provided with modern guns.

According to the official report, England has, in the last fourteen or fifteen years, built one hundred and ten iron and steel war ships, all with modern engines, and this at a cost of $120,000,000; besides this, $32,000,000 have been appropriated for the construction of thirty ships, &c., for the coming year, or a total of over $150,000,000, mainly expended within the last eighteen years, or since the termination of our civil war. Not one of the engines for this fleet was built in Government yards, but all of these and half the hulls were built by private contract. Yet their dock-yards are in a higher state of efficiency than ours, and, as very little influence can be brought to bear politically, are managed more in conformity with civil-service rules and economy. We have spent our money patching up our old war fleet, and as we have no forts, ships, or guns, neither have we, in our navy or private yards, the facilities to make the armor to cover them.

Had our Government pursued a policy, similar to that of England, of encouraging private ship-building, we should, with our skill, energy, and ability, have had, long ere this, the facilities to do all that is needed. But the demoralizing influences of political power are seen in the continual interference with or by the transfer of naval officers from one place to another, instead of retaining their services in any one yard for any length of time, and in the filling up those yards with incompetent labor. All of these are sources of evil which can hardly be measured, and no private establishment could become a success or maintain its high efficiency under similar circumstances. Nor does the Government pay a sufficient compensation for the talent required. I pay my chief constructor $7,500 a year, and my chief engineer a similar amount, and both have been with me for fifteen years. I could not conduct my business with success were I every few years to get some one to take my place and change my leading men. No matter how conscientious my foremen may be, they do not take the same interest as if they were owners in the concern; and no matter how faithful the officers in your navy-yards are, the yards are not theirs, and under such circumstances they cannot compete with private establishments.

Mr. MORGAN. What progress has been made in the construction of iron and steel ships in this country during the last fourteen years?

Mr. ROACH. There were, comparatively speaking, no facilities for building iron ships in this country in 1870. A few iron ships were built for the Government during the war, and a few vessels of from 1,200 to 1,500 tons were built for the merchant service, but in the most expensive way, owing to a lack of facilities. One made the iron, another built the hull, another the joiner work, and still another the shafts, and so on. Not a single compound engine was then built in this country. England built them for herself, and for all that needed them. So little confidence had our merchants here in our ability to build compound engines that they asked special legislation of Congress to have them imported free of duty, and the Navy Department, during General Grant's

first term, sent the chief of one of the bureaus to England to buy a compound engine for the United States steamer Tennessee. I opposed this policy, and explained to the President that as we had eight navy-yards and a few private workshops, we either ought to build those engines at home, or if not allowed to build them at home, we ought to import the man to teach us how, as we had the material. How would the American mechanic like this? I went before the committee of Congress, opposed the policy of allowing compound engines to come in duty free, defeated the measure, and proposed to the Government and the merchants to build the compound engines they required at the English prices, duty added, guaranteeing results equal to the best in the world. And I succeeded. This is the history of the first compound engine built in America for ocean service, and for advocating this policy of building in private yards the free-traders and the politicians around the navy-yard paid particular attention to me through the press. An American company, in 1872 contracted for three pairs of compound engines in England. The price paid for them free on board on the Clyde, without freight or duty, was $95,000 each. Since then I have built for the same company thirteen ships with compound engines at 20 per cent. less than the English price in 1872. England at that time had the monopoly and profited by it.

Had we then passed the law allowing compound engines to be imported duty free, the one hundred pairs constructed by me, from our own ore and by our own labor, would not have been built. As a consequence, we would be depending on England, would be paying her more than what we could build them for at home, and to-day would be not only without the plant and skilled labor, but have to ask her for our compound engines, as we do for our steel armor plates. Besides, in building these engines at home, we have educated an army of skilled laborers, who will be able to fill our navy-yards when needed in time of war.

Mr. MORGAN. What is the present condition of our steam merchant marine?

Mr. ROACH. It is very efficient. Of the ninety-one ships I have built in my yard, fifty-three are between 5,200 tons and 2,000 tons burden; twenty-five are in the foreign trade, with a tonnage of 63,000 tons, and have a speed of from 12 to 15 knots an hour; the remaining thirty-eight have a tonnage between 2,000 and 700 tons, and a speed of from 12 to 15 knots. These, with what have been built in other yards, would make a fleet of iron ships second to no other nation's but England's, and three-quarters of England's fleet of iron ships have only a speed of from 8 to 11 knots. England's fast merchant marine is confined to her mail and passenger ships, and those which do her cargo-carrying are so very slow that as cruisers, in the event of war, they would not compare in speed and light draught with our ships.

Mr. MORGAN. What benefit would our merchant marine be to us in case of war?

Mr. ROACH. Our merchant marine would bear the same relation to our Navy that the militia does to our Army, costing the nation little in time of peace, though forming a great power in war. Our merchant marine should be our militia for the sea, ready at a day's notice to be called on, with its organized captains, engineers, and crews. The modern manner of conducting war is different from that of former days. A nation with home ports well protected must next protect her ships on the high seas. England's shipping may be well compared to our trunk railroads, for as an enemy by destroying England's cargo fleet would cut off her means of bringing produce to market, so if a hostile force

were to destroy our railroads the same effect would obtain with us. England has no home raw material except iron and coal, and as she cannot raise wheat enough to supply her own demands, her condition with this interest seriously menaced can easily be imagined, more particularly as the greater portion of her fleet, which is very slow, would be helpless when brought in contact with faster vessels. It would be a wise policy for our Government to offer some inducement to American capitalists to build lines of very fast steamers, manned by Americans, and to open trade with such countries as require our products. These lines would make a powerful navy in themselves to attack an enemy's commerce.

The ships built in my yard alone would, with their great speed, and if well manned, be of more dread to a nation having a large commerce on the sea, in case of war than would our whole existing navy.

Mr. MORGAN. How does the cost of iron ships compare now with the cost when you commenced building them 14 years ago?

Mr. ROACH. Iron ships are built now for less than ocean-going wooden steamships were before the war, and for less than they were built in England in 1870.

Mr. MORGAN. Has this been produced by a reduction in the price of labor?

Mr. ROACH. Not to any great extent. When I commenced building iron ships I examined the whole field, both here and in England, and I found that there was not a single establishment, either in England or in this country, which then built a ship complete in itself. One party built the hull, another constructed the engines, another made the shafts, another did the joiner work, another the painting, another the copper work, plumbing, &c., so that as it took six or seven different parties to complete a ship, as many more managers and superintendents were required. I desired to organize one establishment in which I could build complete ships, from the ore up, though nothing of this kind was ever done in England or this country. And yet, before the war, New York built four-fifths of all the ocean steamers which were constructed in America.

There were, then in New York and Brooklyn, seven yards and five large marine engine shops, one large forge, several joiner, paint, and coppersmith shops, all with a capital invested in lands, buildings, and tools, of not less than $6,000,000. I decided that with improved machinery one yard could be established under one management, and with one-quarter the capital, which would produce more work than all the other yards combined. In twelve years the tonnage of the ships I have built has amounted to more than all the other yards referred to turned out in any twelve years that they were in existence.

Mr. MORGAN. To this, then, you attribute the reduction in the cost of the ships?

Mr. ROACH. This had much to do with it.

Mr. MORGAN. What else helped to reduce the cost?

Mr. ROACH. When I began iron-ship building I sent a man to England to study their improvements, and I found that iron ships were built there just as we were building wooden ones—that is, five or six establishments were required to complete a ship. The plates then used for a ship were generally 12 feet long by 4 feet wide, or a surface of 48 square feet in a plate; and when a builder wanted a plate larger than this the mill owner would charge an extra price for it. As I decided at once to build my own mill, and to make the plates to suit myself, I rolled the plates for shell of ship 5 feet by 14 feet, or with 70 feet of surface, against the English 48 feet, and thus saved at once over 40

per cent. in planing, chipping, calking, and punching. I made my deck plates 18 feet by 5 feet, or with 90 feet of surface; this plan made a better ship, for there were fewer butts to strain, and it reduced the cost of iron-ship building very largely without reducing labor. Of course other mills improved in the same manner, and ship plates can now be made, by several American mills, suitable for those required by the ship builder. This change, while reducing the cost of the ship, did not reduce labor.

The committee, I believe, are looking into our present means of defense, and to what extent we are capable of creating this. Let me say that we have the material and skilled labor, but not the plant. It may be interesting to the committee to know what other nations are doing in the construction of armored ships for their coast defense, and for the attacking of cities, &c., on an enemy's coast.

England, as I have already shown, has constructed in the last sixteen years a fleet of powerful iron-clads and war-ships, costing $120,000,000, and for the coming year has appropriated $30,000,000, making a total of $150,000,000. Many of these ships cost over $3,000,000 each.

France, in the same time, has built five ships of a very powerful class, costing $14,000,000, and sixty armored ships, at an expense of $75,000,000, or a total of $89,000,000.

Russia has built 5 armored ships at a cost of $7,025,000, and one, the Peter the Great cost $2,800,000. Besides she has built 25 armored ships and 43 unarmored ships and gunboats at a cost of $35,460,000, or a total $45,285,000.

Italy has built in the Duilo class the most powerful iron-clads afloat; 5 of this class cost $18,500,000. She has also built 10 armored ships at a cost of $9,500,000. That is a total of $28,000,000.

Germany has built 5 modern war ships of the King Wilhelm class, at a cost of $9,330,000; 10 armored ships at a cost of $9,450,000; 21 armored ships at a cost of $15,167,000; 36 unarmored ships at a cost of $12,000,000; or at a total cost of $45,947,000.

Austria has built 32 of the modern class, costing $19,000,000.

Turkey has built 13 armored and 5 unarmored, at a cost of $17,300,000.

Add together what these nations have expended for the construction of modern war ships, and it will be seen that this reaches the enormous sum of $394,532,000.

If any of these nations were to send a fleet of these powerful iron-clads over here, it could pass any of the defenses we provide for our cities, as we have no forts, ships, nor guns which could stop it.

What has the United States done in the same time? In 1873 $3,200,000 were appropriated, and with this amount compound engines were built and put into the wooden hulls which remained unfinished in the navy-yards after the war, and the wooden steam frigate Trenton was built. This amount and the $2,400,000 for the four cruisers, or $5,600,000 in all, constitute the appropriations which have been made for a modern navy. Congress has continually refused to take the first step toward the building of a modern navy. When the war closed our Navy consisted of vessels built without any regard to the requirements of a future fleet. When the required ships were constructed, compound engines were not in use. The timber was in the forest, was cut, and put into the ship green; consequently the ships rotted very soon. When the war closed we had not a single modern war ship. What we had were very slow, were very large consumers of coal, and fitted with engines of old type. England, France, or Germany would not have taken them as a gift on the conditions that they would keep them in repair as we have done.

Congress passed laws allowing from 20 to 40 per cent. of the first cost of the ship to be expended upon her repairs; and yet no man could be found who would give for them, after they were repaired, the cost of repairing. The excuse was, if you don't build a new navy you must give us something with which to repair our old one. We must show our flag upon the seas.

That would be well enough in time of peace, but these patched-up vessels for war purposes, without armor, speed, and modern guns, would only be death-traps for the brave officers and sailors who would go in them to meet the fleet of any other nation.

UNION IRON WORKS, CALIFORNIA.

STATEMENT OF MR. IRVING M. SCOTT.

SAN FRANCISCO, CAL., *September* 27, 1884.

Mr. MORGAN. What is your full name?

Mr. SCOTT. Irving M. Scott.

Mr. MORGAN. How long have you resided in San Francisco?

Mr. SCOTT. Twenty-four years.

Mr. MORGAN. What has been your calling?

Mr. SCOTT. That of foundryman and iron manufacturer in its various branches, and in addition for the last three years I have been engaged in making pig-iron from the native ores.

Mr. MORGAN. What facilities have you in your establishment at present for building steel or iron ships?

Mr. SCOTT. We have every facility, in the Union Iron Works at San Francisco, required for building steel or iron ships, and supplying them with the motive power, and with furniture and fixtures.

Mr. MORGAN. Are you now engaged in building ships?

Mr. SCOTT. We are building an iron caisson for the Government dry-dock at Mare Island, and a steel collier for the Newport Coal Company.

Mr. MORGAN. From what source do you get the steel?

Mr. SCOTT. At present from the Pacific Rolling Mills, next door to our works.

Mr. MORGAN. Where are the keel bars and stern posts made and of what size are they?

Mr. SCOTT. The ingots are made at the Pacific Rolling Mills. The keel bars are 7½ inches deep and 2¼ inches thick, by 200 feet long, in four lengths. The stern post, which carries the rudder and propeller, is considered a very difficult piece of forging to make, the most difficult about a ship, and the one you saw at the works is as good as I ever saw in any part of the world; they can be and are made by the Pacific Rolling Mills as cheap as we could get them anywhere in the world. All the T irons and angles used in the ships are of the best grade of steel, and this steel is made in a Siemens and Martin open-hearth furnace, in San Francisco.

Mr. MORGAN. Where do they get the metal?

Mr. SCOTT. In their experiments they have tried metals from Roach's establishment, at Chester, Pa., and some imported from England, and some from different parts of the United States; and they have experimented with iron made in Placer County, California; also iron made by the Puget Sound Iron Company; also with Oswego iron from Portland, Oregon. In their experiments they have reported to me that the ores and iron from the California Iron and Steel Company in Placer County* is of a quality that enables them to manufacture good steel without any admixture of any other ore; and they find their best results in steel making from the California ores.

Mr. MORGAN. In what quantity can they use the metal in their furnaces?

Mr. SCOTT. With their present facilities they can make steel castings of 20 tons. They can add other furnaces in about three months by

* Only mine in California being worked. C. G. Yale. ("Mineral Resources," 1883–1884, A. Williams, jr.)

which they will be enabled to make a casting of 120,000 pounds in one piece. * * *

Mr. MORGAN. Before going into a more minute inquiry upon the subject of production of steel, I will ask you about the fuel along this coast. Is it easily available?

Mr. SCOTT. It is available from the sea or by railroad.

Mr. MORGAN. I will be glad to have as full an information as your knowledge permits on this subject.

Mr. SCOTT. As far as the native coals of California are concerned we have no true coals, as yet discovered—nothing but brown lignites—which answer for ordinary fuel purposes. Take the value of Cumberland coal as being 95, the value of California lignites, for steam purposes, would be 45 or 55. The coals of Oregon are of better quality and are improving—the discoveries get better every year. The coals of Washington Territory are still better, and we have the promise of being able to get a good coking coal. We now produce average coal for use in the ordinary course of machine work. The Carbon Hill coals of Seattle make good coke. There is also some anthracite coal on Queen Charlotte's Island, and 120 miles inland from Guaymas. The following tables give the exact quantity and value of coals obtainable in San Francisco:

Name.	Locality.	Efficiency of furnace.	Pounds of water evaporated at 212 degrees per pound of coal.	Units of evaporation in foot-pounds of work.
Anthracite	Pennsylvania	64	9.68	7,218,879
Lackawanna	Pennsylvania	62	8.02	5,981,316
Cumberland	Pennsylvania	62	8.	5,966,400
Sydney (Wallsend)	Australia	62	6.96	5,190,168
Hamma	Chili	62	6.	4,474,800
Black diamond	California	62	5.4	4,027,320
Independent	California	62	4.4	3,281,520

Name.	Locality.	Specific gravity.	Volatile combustible matter in 100 parts.	Fixed carbon in 100 parts.	Earthy matter or ashes in 100 parts.	Water in 100 parts.
Lehigh	Pennsylvania	1.590	5.28	89.15	5.56	.....
Cumberland	Pennsylvania	1.313	15.53	76.69	7.83	.....
Sydney	New South Wales	1.338	23.81	67.57	5.49	.....
Newcastle	England	1.257	35.83	57.00	5.40	.....
Sagahalia	Liberia	1.288	35.70	56.45	6.05	1.80
Cannel	Lasmaho, Scotland	1.228	49.34	40.97	6.34	2.90
Specimen	.....	1.282	40.20	49.70	3.00	6.70
Black diamond	California	.....	33.89	46.84	4.85	14.69
Bellingham Bay	Washington Territory	.....	33.26	45.69	12.66	8.39
Nanaimo	Vancouver's Island	.....	32.16	46.31	18.55	2.98
Coos Bay	Oregon	.....	32.59	41.98	5.34	20.09

Mr. MORGAN. Where is Queen Charlotte's Island?

Mr. SCOTT. Off the coast of British Columbia, between latitude 58° and 55° and longitude 135° and 130°. We are also accessible to the coal markets of the world. Australia furnishes good coal, and we get coal from Cardiff, Wales. We get the best fuel coals from Australia; but while we do not produce such coal here, our coal for steam and for some manufactures is good. The progress of manufacture is

such as to indicate that the gas made from coal will do more work than the coal itself, and this may increase our advantages. In addition to this we have large deposits of oil—petroleum—which we look upon as the future source of supply for good fuel, and these things are within reach at fair prices, and will be developed as rapidly as circumstances permit.

Mr. MORGAN. What is the relative cost of transportation of coke and coal from Philadelphia or New York and Cardiff?

Mr. SCOTT. The cost is about the same. We sometimes get coal as low as $8 a ton from New York, and again it is as high as $12; we can get it transported from Cardiff at about $8. The cost of transportation from Australia depends upon whether the ships come for wheat or not. When a ship comes for wheat she brings coal as ballast, and sells it from $6 to $8 per ton. The prices fluctuate.

Mr. MORGAN. Are any coals brought from the Aleutian Islands?

Mr. SCOTT. No, sir.

Mr. MORGAN. Or from Japan?

Mr. SCOTT. Not to any extent. There is a little in the southwestern part of the island, but it is not developed. There are all kinds of minerals in Corea, but they are not yet made available to the outside world.

Mr. MORGAN. How do you produce your pig-metal in Calfornia?

Mr. SCOTT. The production of pig-metal in California is conducted entirely with charcoal; the charcoal is made of oak and what is known as scrub pine, and costs at the furnace from 8 to 11 cents a bushel. The average cost is about 11 cents. In the ores that the California Iron and Steel Company used in manufacturing 8,000 tons of pig there has been an average of 100 bushels of coal to the ton of iron, and a yield of 53 per cent. of iron to the ton of ore. There is more ore in sight at the bottom of the shaft than ever before in the history of the mine, and it is better than when prospected on the surface.

Mr. MORGAN. Is limestone abundant that can be used for fluxing?

Mr. SCOTT. California is full of limestone suitable for the purposes of agriculture. Plenty of the mines are pure, but not all suitable for fluxing. But we have anything you want in the way of fluxes, and in great abundance.

Mr. MORGAN. Are the forests of pine and other woods situated conveniently to the ore beds?

Mr. SCOTT. Very; the early selection of timber land was made with a view to lumber. Along the foot-hills and the streams where the flumes are, there this land has been taken up, leaving great bodies of inferior timber near the ore beds suitable for charcoal.

Mr. MORGAN. Does the country reproduce timber when cut down?

Mr. SCOTT. Rapidly; the tendency is to produce forests. The land where the timber has been cut down is kept for agricultural purposes. That in the foot-hills is valuable for grape purposes. The suppression of fires also has a tendency to produce forests. The capacity of California for this description of fuel is practically inexhaustible. I will state further, from intimate knowledge of the subject, that we can supply any demand that may be made from any source whatever for charcoal iron.

Mr. MORGAN. These ores lie west of the Sierra Nevada Mountains.

Mr. SCOTT. There is no county in the State that is without some supply of ores.

Mr. MORGAN. Do these ores run high in phosphorus and sulphur?

Mr. SCOTT. It exists in traces in many—some run 2 per cent. The ores of the California Iron and Steel Company go less than one-quarter

of 1 per cent. of sulphur, and no phosphorus. We have broken and drilled the pig-iron and assayed the drillings.

Mr. MORGAN. We would infer from that that the best qualities of the steel and iron of California are free from phosphorus and sulphur.

Mr. SCOTT. Yes, sir; good steel cannot be made where phosphorus exists in large quantities, though a great change has taken place since the introduction of the basic process.

Mr. MORGAN. Is there any real difficulty in transporting or sending these ores to the Bay of San Francisco from these different places?

Mr. SCOTT. No, sir. In my judgment the proper thing would be to erect the furnaces at tide-water, have deep-sea ships bring coal, coke, or oil to the wharf, and have fixed prices for the iron ores of certain per cent. delivered at the furnaces. There are many localities in which good iron ore is found in California, and we can produce anything you wish in the shape of charcoal iron.

Mr. MORGAN. You spoke of iron and steel manufacture in other countries; will you give some statement of your own observations in other parts of the world, that is, a general statement?

Mr. SCOTT. In February of 1880 I left San Francisco on a trip of pleasure and observation, and my special attention was drawn to the manufactures of iron and steel. The next prominent object of my travel was to examine the tools and other appliances of the manufactures of the different parts of the world, for the purpose of erecting in San Francisco one of the most complete plants in the world. That plant is now in operation in San Francisco.

Mr. MORGAN. Was there anything in Japan or China or India capable of supplying commerce or the governments there with heavy guns, or steel or iron ships, engines, or their necessary appointments?

Mr. SCOTT. No, sir; none at all. Practically from the Red Sea to Japan, all Asia is supplied by Europe or America. * * * America has the foundation to supply that part of the world and ought to do it.

Mr. MORGAN. Is there anything in South America that can be called a successful iron and steel manufactory?

Mr. SCOTT. No, sir; none; judging from the fact that their locomotives and ice machinery and milling machinery all come from other countries. Some of their mills have been supplied from this State. I believe there are also no works in Mexico. During my examination of the works in Europe I found no facilities of a national character, or of size conspicuous enough to spend much time on until I came to Essen, Rhenish Prussia. In Belgium I saw the greatest mechanical skill in all mining appliances, and they might be called the Yankees of Europe. I saw no country possessed of knowledge in ship-building to compare with the Clyde Scotchmen, and at Aberdeen; and no establishment superior to Schneider & Co. at Le Creusot. In all the countries I visited I saw no manufacture of steel or iron, which, with the money to pay for it and the time to construct it, I would hesitate to attempt. American mechanics are equal to any demands that can possibly be made by the Government, or from any other source.

Mr. MORGAN. What is the leading description of manufacture at Essen?

Mr. SCOTT. Steel materials and guns for the German Government. Guns first, and large steel shafts for the world. They used, for putting their ingots into shape, a large hammer, of 50 tons capacity, built in 1859, and costing $560,000. They are now building a hammer that will strike a blow of 150 tons,* whose foundations will cost $1,000,000, and the whole structure in the neighborhood of $2,500,000.

* See page 466. (Chairman.)

There is nothing about them which we cannot overcome; the skill and knowledge that is required to construct the heaviest ordnance can be obtained in our own country. At the works of Le Creusot they have no larger facilities than Krupp. They have one 100-ton hammer and one of 40 tons, and they have some wonderful products in the way of sheet iron and steel which showed the skill of the workmen and the accuracy of their machines. The Whitworth hydraulic forging-press is used in place of the steam-hammer at the Whitworth works in England.

Mr. MORGAN. Which method of compressing is the best, in your opinion?

Mr. SCOTT. The hydraulic compressor; it leaves a more uniform texture and a denser product than the hammer; the pressure can be continued longer, and is more effective than the blow from a hammer. In the future, I think, gas, made from coal or oil, will be used for heating and Sir Joseph Whitworth's hydraulic press for forging.

Mr. MORGAN. What is your view, founded upon observations of your own, as to the relative cost of a hammer of the greatest power and of an hydraulic compressor of equal power?

Mr. SCOTT. In Krupp's works the statistics can be obtained. A hammer to forge an ingot of steel for an 160-ton gun would, with its accessories, probably cost $3,000,000; while an hydraulic compressor, would cost not more than $300,000; furnaces and cranes, $550,000; total, $850,000.

Mr. MORGAN. Which do you think is the cheaper machine to work in handling heavy masses of steel, the hammer or the compressor?

Mr. SCOTT. The compressor. Our experience for ten years has shown that an hydraulic machine is preferable to a rotary machine. We have one for punching, shearing, and pressing into shape all the parts of boiler plates. It is as complete and economical as to time, and is no more costly; it leaves a greater density to the materials because the fibers arrange themselves, while being compressed, in their natural order. The progress of the mechanic arts points to the use of hydraulic compressors in place of hammers. We use hydraulic power for almost everything. Even the doors of our establishment are opened and shut by it. The cost of operating hydraulic machines is not as great as that of running a rotary machine, and the tools are much cheaper. A rotary punch, for punching a hole through half-inch steel plate would weigh 19,000 pounds, while the hydraulic device would weigh about 7,000 pounds. It can be placed in any suitable position, and would only require a small pipe leading to it, while the other would have to be in a convenient position to belt on from a rotating shaft; at present we lead an hydraulic pipe from our accumulator over to our wharf and shipyard, and there arrange our punch to suit our purpose, near to the work at hand. The distance is 600 feet, but it can be carried just as well 6,000 feet. Another great point is, that when we are not using a tool we are not expending any power, while in all rotary machines the counter-shafts to which they are bound continue to rotate, the friction of which is a constant use of power.

Mr. MORGAN. Is there any concealed art or knowledge in respect to the handling of metals, so that hydraulic compressors are not generally available to the skillful and scientific manufacturer of metals?

Mr. SCOTT. None whatever. The keystone of the hydraulic compressor is strength. The amount of power required to compress an ingot weighing 160 tons is simply a matter of calculation. You first have got to get a press that will stand the required pressure, then you put on the power and make the desired result.

Mr. MORGAN. I suppose you have had an opportunity to test the relative strength of shafts made by compressors and those made by hammers?

Mr. SCOTT. We have tested the relative quality of shafts made under hammers and under rolls. In every case where the rolled iron was made under rolls of sufficient size the rolled shaft has been more homogeneous and more reliable than the hammered. It is a well-known fact that no hammered solid shaft of 14 inches or upward is ever solid in the center. You can find soft or spongy places as big as your hand in the best of them. The steel shafts for the steamship City of Rome were cast with a hole right through the center. They were of cast-steel, and were rolled after being cast, so as to press them and make them more dense and uniform. I did not see the rolling but they were rolled.*

Mr. MORGAN. Would you be willing to take a contract for the building of an hydraulic compressor here, of sufficient capacity to make material for guns on the Krupp system of 100 tons weight?

Mr. SCOTT. We would be glad to have the contract, and we would have no doubt in undertaking the contract for so large an affair. There is no doubt about our capacity to build as large a gun as could be done in any part of the world. We are confident in our capacity.

Mr. MORGAN. Would you go so far as to say that in putting up such machinery as we have been talking about you could do it entirely with California material?

Mr. SCOTT. Yes, sir.

Mr. MORGAN. Of course you mean that you would have to bring your fuel from elsewhere?

Mr. SCOTT. In making the appliances and constructing the instruments we might be obliged to use some materials from the other side of the continent of America, but when once constructed California can supply everything without going abroad for a single thing. We might have to go to the Atlantic States for the raw materials, such as coal or coke and tool steel, for the manufacture, but could construct all the necessary tools in California which would be required to make such a compressor, and then we could construct the compressor here, and would not have to go outside of the State, except as a matter of choice.

Mr. MORGAN. Would you consider it a fair profit if you were allowed the difference between a Whitworth forging press, duty free, and the duties now imposed?

Mr. SCOTT. We would be glad to accept the contract with the understanding that the duty upon the Whitworth press should be our reward. and that we should have continuous work; we would furnish everything else at absolute cost to the Government. I feel confident that the price the Government would pay would be as low as any it could get in any foreign country; besides it would be distributing the money among the mechanics of our own country. The immense establishment of Krupp, at Essen, has been cared for by the German Government; the works of Mr. Schneider, at Le Creusot,† have been cared for by the French Government; and those of Armstrong & Whitworth,† by the English Government. If there is any lesson in the history of these facilities it points to the fact that the United States Government, to make itself independent of the rest of the world, must support these industries in its own borders.

Mr. MORGAN. What would be the expense of putting up a Whitworth hydraulic forging-press and plant, to make a gun of 100 tons at San Francisco?

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* See page 23. (Chairman.)

† Advised by the company that they have never received Government aid. (Chairman.)

Mr. SCOTT. The total expenditure would be $1,850,000.

Five open-hearth furnaces	$250,000
Fluid compressor, cranes, pit, &c	350,000
Reheating furnace	150,000
Forging press	300,000
Cranes for the press	240,000
Tools for turning, boring, shearing, and incidentals	200,000
Tempering pit	50,000
Traveling crane (capacity 160 tons)	60,000
Buildings, incidentals, &c	250,000
Total	1,850,000

The person who undertakes this ought to have $2,000,000 worth of work a year from the Government to get the interest back on the money invested, and it would take ten years to get the investment back.

Mr. MORGAN. Leaving out the armament, that is to say, the guns, if you were to set out to make a steel ship in the Bay of San Francisco exclusively of California material, beginning with the ores and ending with the ship ready for sea, what additional facilities besides those which you have would be requisite?

Mr. SCOTT. Simply the mill for rolling plates of steel; we have everything else. We are now constructing two boilers of steel plates 1 inch thick, each of which will weigh when finished 78 tons. They are 14 feet in diameter, 22 feet long, and are to carry 100 pounds of steam to the square inch. They are larger than any boiler that would be required in any Government ship now afloat. We have steam shears capable of putting in place weights of 100 tons. We have hydraulic shearing machinery in operation at present, with a capacity to shear a sheet of steel 1½ inches thick and 14 feet long. The shears are of steel, and all parts of them, including the knives, were made at our own works. That is, they were made of steel produced by the Pacific Rolling Mills and finished by us. We also have planing machinery for trimming the edges of plates perfectly true. It cuts both ways, will plane a sheet 25 feet long, and will take in armor plates 18 inches thick. The sheet is put into the machine and held in position while there by hydraulic appliances. It is up to the latest requirements of the business. It was made in our own works, including all the appliances and appurtenances belonging to it. We also have rolls for rolling plates 1½ inches thick, 14 feet wide, and in any length required. We have a machine for drilling such plates, with four spindles in operation at one time, and we drill four sheets at one operation. We also have three hydraulic riveting machines for driving the largest steel rivets now required; also a traveling crane run by hydraulic power, for handling and operating weights as large as 70 tons. These tools, with all their minor appurtenances for a complete plant are in operation in one department known as the boiler shops. In our engine shop we have a machine for turning crank shafts and propeller shafts, which will take a shaft 43 feet long and 3 feet in diameter, and will cut a screw, according to the Whitworth standard, of any required pitch or size that is practicable in modern mechanics. We have planers 12 feet square and 30 feet long, supplied with all modern appliances, and boring mills that will bore a cylinder 12 feet in diameter and 30 feet long, if you want them. We have, in course of erection, built by ourselves, a compound machine that will bore, plane, or turn. It is intended to turn material 30 feet in diameter and with 10 feet of face; plane vertically 10 feet; plane horizontally 30 feet; bore out the center of a wheel of any size up to 30 feet in diameter; cut a key set through the hub; and plane the edges of segments of wheels;

the largest pulley or fly-wheel or rope wheel required in modern mechanics can be placed upon its table or face plates, and every operation required to put that wheel together, turn key-seat, and finish it, will be done without moving the wheel from its place. This machine will be the largest and most complete of its class in existence; it will occupy a space 50 feet square and 43 feet high. The machine will be served by a 50-ton overhead traveling crane, which will be moved back and forth by rotating engines, driven by compressed air, but the lifting will be done by hydraulic machinery driven by the same engines.

Mr. MORGAN. Are you working a Corliss engine?

Mr. SCOTT. No, sir; the engine you saw is our own invention. We have proved that our engines, when put in flouring-mills, and at hard work, excel the Corliss engine, or any one eccentric engine.

Mr. MORGAN. What is the largest-sized engine you have ever built?

Mr. SCOTT. The largest stationary engine we ever built was the pumping engine for the Nevada mines, at Virginia City. That is a compound condensing engine, with two cylinders, the initial cylinder 65 inches, and the expansion cylinder 100 inches in diameter, respectively, 12-feet stroke; fly-wheel 33 feet in diameter and weighing 100 tons; the shaft is of wrought iron, 28 inches in diameter. The engine is used for pumping water from the Union shaft, 3,100 feet in vertical depth. We built that machine and had it running over there in six months. We made everything for it. We got the shaft and forgings from the Pacific Rolling Mills; they were hammered there. This great engine was entirely of California manufacture.

Mr. MORGAN. What column of water does it raise?

Mr. SCOTT. Two lines of pumps, 16 inches diameter and 10-feet stroke, perform a duty of 93,000,000 foot pounds with 100 pounds of coal or its equivalent.

Mr. MORGAN. How long has this engine been in operation?

Mr. SCOTT. Since the fall of 1879, and is still at work.

Mr. MORGAN. Does it work as well as ever?

Mr. SCOTT. Oh, yes; on the Yellow Jacket shaft there is compound condensing engine, 12-feet stroke. The initial cylinder is 37 inches, and the expansion cylinder 65 inches in diameter. This shaft is about 2,800 feet deep. I could mention a dozen engines made right here by different builders that equal in size any engines in the East.

Mr. MORGAN. You have made a number of these large, heavy engines?

Mr. SCOTT. Yes, sir; and pumps of all sizes, with all their appurtenances, also air compressors and mills, and metallurgical appliances complete, from the assay of the ore to the smelting; even the little machine run by compressed air, for depositing the chloride of silver in assaying.

Mr. MORGAN. In your examinations in England and Belgium, did you find anything as heavy and powerful as the engines you have erected here?

Mr. SCOTT. Nowhere anything as large. In Belgium there is the best mining machinery in Europe. In England I found their winding engines attained greater speed than those in Belgium. The maximum speed in the English winding engine was about 4,700 feet per minute. The hoisting engines of the Union shaft, Virginia City, Nev., built by us, are a pair of direct acting engines, with 28 inches diameter of cylinder, 8-feet stroke, and running at sixty revolutions per minute, that is, 960 feet of piston a minute. They hoist at the maximum speed of 5,200 feet a minute. The necessities of deep mining in California has made

a demand which has developed this machinery. There are 1,400 tons of machinery in one of these engines.

Mr. MORGAN. Where do you get your material?

Mr. SCOTT. Prior to the war we depended upon England and France entirely for pig iron; upon England for the lower grades and upon France for the higher grades. We sent to England also for plate and tubes. After the war, after the revival of our industries, we were enabled to do better in quality and prices from the American manufacturers. To-day, pig iron, boiler plates, and tubes are all of American manufacture. With the exception of some low-grade English iron, brought in ballast by wheat ships, the products of California and Oregon have entered largely into the consumption the last few years, with ample ability to supply the wants of this coast. The annual consumption of pig iron in California is about 20,000 tons; two-thirds of it is American iron, and 4,000 tons come from California. The cheapness of transportation by sea has very materially interrupted the production of iron on this coast.

Mr. MORGAN. What is the cost of pig iron imported from England?

Mr. SCOTT. Twenty-four dollars and sixty-five cents a ton is said to be the exact amount for which the best grades of pig iron can be imported. That fixes the price of the home product. The freight from the works of the California Iron and Steel Company, Placer County, to San Francisco is $2.75 per ton of 2,000 pounds. The profit to-day on the manufacture is $3 a ton. The tariff is $6.72 a ton on all grades of English iron, which is double the profit now made on this coast in the manufacture of pig iron.

Mr. MORGAN. Do you find any material advantage, in such works as you conduct here, in the use of charcoal pig?

Mr. SCOTT. Yes, sir; it is a very much better quality of material, and is cheaper to mold and finish; besides, its great strength enables us to make lighter castings of the same strength.

Mr. MORGAN. To what extent is piping and tubing made on this coast?

Mr. SCOTT. Wrought-iron pipes, for hydraulic mining and waterworks, have been carried to a development unequaled in the world; boilers and cheap water services are also made here, but neither boiler tubes nor gas pipes are made here at present. There is a large demand for tubes and gas pipes, and all indications point toward the early establishment of these manufactures here. The industries are filling up. The last year has seen the addition of a cotton factory at Oakland; the year previous, a nail factory; also, one for making tacks and files by machinery; also, mowing machines and cotton-knitting factories. All of these have been added since 1881.

Mr. MORGAN. Taking the whole field together, over which you have been going in a cursory way, have you any doubt of the ability of California, through her ports, to supply all the essential manufactures of steel and iron, including all descriptions of machinery, and ships of steel and iron, to the trade of the Pacific Ocean?

Mr. SCOTT. Not the slightest.

Mr. MORGAN. Do you believe that after a fair start, and capital has been diverted in that direction largely, you would have any difficulty in competing with European countries?

Mr. SCOTT. Not the slightest. While labor and fuel are somewhat higher, the climate is such that we can work out of doors during the entire year, and the men do more average labor the year round than in any other State I have visited. If a man purchases a ship in New

York for the California trade he must not only advance the money, but he must be without the services of that ship for four months at least, with all the risk of coming around the Horn, and damage done the ship to be paid for. For instance, we have just put 22 feet of a new stem in and new plates on the Topeka, which was injured in the Strait of Magellan. If the ship were built here the interest would be saved, and the owner would in every way get an article more suitable than one brought from abroad; besides, a trip around the Horn is considered equal to one year's ordinary wear on the boiler. We manufacture the boilers required of the highest quality of steel and at prices which pay the manufacturer a fair profit in San Francisco at less per pound than has been paid for the boilers of some steamships lately built on the Delaware for service on this coast.*

The condition of our workmen is prosperous. They own their own houses and homesteads to a greater extent than most other communities. The laws protect them to the extent of $5,000, by exemption from all debt upon a declared homestead, and the workmen of San Francisco are the best paid, the best clad, the best fed, and the best housed workmen in the entire world. Having visited most of the cities of the world and examined the condition of workmen, I adopt this as a gauge.

Mr. MORGAN. How much of his earnings does it take for him to live, and how does he live? What sort of clothes does he wear? What does he feed upon? What kind of a house does he live in?

Mr. SCOTT. I found that in China, Japan, Anan, the province of Wellesley, India, Arabia, Egypt, Asia Minor, Turkey, Greece, the Grecian Archipelago, Italy, Austria, Germany, Holland, Belgium, France, England, Scotland, Ireland, the working classes were compelled to expend from seven-eighths to the whole of their earnings to eke out an existence far below the average of American mechanics, while the American mechanic, as he exists all over the United States, uses from a half to three-fourths of his entire earnings. In all the places that I visited the cost of labor did not seem to vary much; that is, if you paid 10 cents a day for labor in China it took ten men to do what one man in Europe did for a day's work for one dollar.

Mr. MORGAN. What is the known amount of deposits in the California savings institutions in San Francisco?

Mr. SCOTT. In the Hibernia, Clay Street, German, French, and other savings banks of San Francisco the working classes, both men and women, have had, at times, deposits aggregating between $76,000,000 and $83,000,000; and now (1884) they amount to $59,923,749. I may be in error as to the total amount, but I can verify it. There is the Clay Street Savings Bank, which has had something like $12,000,000; and there was the German Savings Bank, about $8,000,000. The Hibernia Savings Bank is almost exclusively patronized by the Irish women and men, and the total deposits now are $20,000,000, divided between 30.987 accounts, and that of the Clay Street Bank is $2,700,000. The English have a system of taking stock in ships by subscription. This is done at Aberdeen, or at any other well-known ship-building establishment of the North of England. A ship is put on the ways to go into a certain trade, and is estimated to cost so much money. Little subscription books are made up of from fifty to several thousand dollars; the aggregate of these small amounts is the amount the ship is to cost. Any one who has money can go into the office of the company and subscribe from $50 up. That is their interest in that ship, and they can insure their own amount, or let it go uninsured. That has made

Great Britain famous for her merchant marine. In years past the people of San Francisco have been investing in paper securities of no value, and I have no doubt they would invest readily in such an enterprise.

Mr. MORGAN. To what do these investors look for their profit?

Mr. SCOTT. To the profits of the trade the ship is in; the system offers facilities to invest small amounts at low interest, and the investors protect themselves by insurance. In case of total wreck they have their insurance, and there is no possibility by which they can lose their entire investment, while in mining stocks they not only lose their investment but have to pay their share of the deficiency. I believe we will not properly extend coast trade until we build our own ships and our own commerce here. During the thirty-three years California has been a State she has paid into the Federal Treasury nearly $500,000,000. Last year the internal-revenue collections amounted to $3,322,716, and we feel as if we were entitled to the patronage of the Government for such things as the Government uses here at the same price the Government can purchase them elsewhere. The Pacific coast, in supplying to the Government all its Army, Navy, and other wants, its ships, &c., used on this coast, should have the preference at the same prices as any other part of the United States.

Mr. MORGAN. Can you make the armor for war ships here of as good material as can be had elsewhere?

Mr. SCOTT. As good as in any part of the world; as strong and secure as can be made in any establishment in the world; and we are willing to take the contract subject to the tests the Government requires.

Mr. MORGAN. Can you build such engines as are required for the Monadnock?

Mr. SCOTT. They are not more than half as large as engines we have built and are constantly building. The engines used in mining are much more difficult to construct than marine engines. We have marine engines in course of construction as large and difficult to build as those of the Monadnock. I think there are at least one hundred sets of marine engines that have been built right here in San Francisco for propellers and other boats.

Mr. MORGAN. Have you a considerable number of skilled mechanics here?

Mr. SCOTT. There are about 2,500 mechanics in the machine departments alone who reside here and are permanent citizens, and their labor will compare with any other in the world for skill, general intelligence, and sobriety.

Mr. MORGAN. Since your tour around the world in the investigation of iron and steel production you have projected and are now building your new establishment here?

Mr. SCOTT. Yes, sir; and in connection with that we will have a dry-dock 600 feet long to take the largest ships now afloat or that are likely to be; we hope to get it into successful operation some time during the fall of 1886.

Mr. MORGAN. When did you break ground for the new plant of the Union Iron Works?

Mr. SCOTT. The contract for the wharf was made March 22, 1883; the first contract for iron work was made June 2, 1883; the first contract for brick work was made June 9, 1883; the boiler shop was put in operation April 1, 1884; the machine shops, August 15, 1884; the shipyard, September 1, 1884, and the last department, the foundry, made the first cast October 22, 1884; about nineteen months in all. It was made for very large machines and ships we are building, with all the

appliances for heating, bending, rolling, punching, testing, and riveting every part of the materials that go into ships.

Chain, cable, and wire, and hemp rope are also manufactured in this city.

Mr. MORGAN. I was not aware that you made wire here at all.

Mr. SCOTT. A. S. Halladie's wire works is a very large establishment. They can make any size of wire required. and also hemp-rope. There is also a whale-oil refinery in San Francisco. Steam whalers and all their appliances are built here, and they have been successful. Their catch is brought here and refined, and the products are shipped to such places as they desire. These whalers are owned here.

Mr. MORGAN. Is the business of making flour increasing?

Mr. SCOTT. Yes, sir; very extensively.

Mr. MORGAN. Do they get their machinery from San Francisco?

Mr. SCOTT. Yes, sir; we made last year an engine, 32 inches diameter, 60 inches stroke, for a company at Vallejo, which is now making 1,460 barrels of flour each day, and one for a company at Marysville, making 600 barrels per day. We have drawings of appliances for engines, boilers, and appurtenances for the same firm, which will enable them to manufacture 6,000 barrels per day. The engine will be of 2,500 horse-power. These improved roller mills, of smaller sizes, are being established in various parts of the State; those of the greatest capacity seem to center around Benicia and Port Costa. The sugar refinery at Potrero Point, owned by Claus Spreckles, is said to have the largest capacity of any in the world. The machinery (engines, boilers, shafts, and tanks) for that refinery were built in San Francisco. The centrifugals, vacuum pans, and some other machinery, upon which there are patents, were built in New York.

Mr. MORGAN. What about the copper supply in California?

Mr. SCOTT. While it seems inexhaustible, in proportion to present demands, there is no danger of overproduction. Montana and California ores are principally sulphurets of copper, and shipped raw, while Arizona's product is generally block copper. The copper ores and metallic copper can be delivered in San Francisco at less cost than at any other point that I know of. That fact will ultimately cause the erection of a mill for making rod and sheet copper in San Francisco.

Mr. MORGAN. Is there any manufactory for making sulphuric acid?

Mr. SCOTT. Yes, sir; there are large works at Berkeley, Alameda County, California, one at Melrose, and one at South San Francisco.

Mr. MORGAN. So you have no occasion to import sulphuric acid from any other country?

Mr. SCOTT. No, sir; we have all the elements—niter, soda, sulphur, borax, &c.,in great profusion—that are required to make powder in all its various forms.

Mr. MORGAN. Have you any chrome iron ores?

Mr. SCOTT. Yes, sir.

Mr. MORGAN. To what extent?

Mr. SCOTT. Sufficient for all the present or probable requirements of the trade, or demand for them. Chrome iron is used in Philadelphia and Baltimore, and is shipped from Auburn, Placer County, California.

Mr. MORGAN. Is the manufacture of borax and soda extensive?

Mr. SCOTT. There are large deposits at Clear Lake, Lake County, California, and in the neighboring State of Nevada, which will supply all our wants.

Mr. MORGAN. Is the charcoal yield here of good quality?

Mr. SCOTT. It is of fair quality. The best weighs about 25 pounds to the bushel. The best quality should weigh about 28 pounds; the worst here is about 17 pounds. The live oak and nut pine make charcoal that will average 22 pounds to the bushel.

Mr. MORGAN. Have you given any consideration to the best method to be pursued by the Government in the construction of guns of high power, or of armored or unarmored ships of war? Have you any knowledge of the system which prevails in England, Germany, or France upon this subject?

Mr. SCOTT. The method, as I understand it, that exists in England is, that in order to have a certain amount of iron armor and steel plates when they are required, without keeping up its own plant, the Government agrees to take, say, 1,000 tons a month from a steel maker, for which it agrees to give him 2 pounds sterling a ton profit, and to pay him this profit monthly, whether it takes the steel or not, on the condition that he shall reserve a capacity to furnish 1,000 tons per month if called upon by the Government. In Germany the Government depends entirely upon Mr. Krupp, and in France the Government depends upon private establishments for all material, and does all the finishing itself. In regard to what would be the best method for our Government to pursue, I am of the opinion that for the Pacific coast, the best plan would be for the Government to aid the local manufacturers in developing a plan that would be equal to any emergency possible to the General Government. The geographical position of the Pacific coast excludes it from the line of other customers, and it is not probable that any aid could be obtained in the way of orders from other nations; hence the greater aid required from this Government to maintain implements useless in every-day work. This method would save the Government the expense of the machine-shops, boiler and foundry plants, and ship-yard; and, in view of what has been done by other Governments, it seems to be the cheapest, safest, and only plan practicable, when we take into consideration the fact that with the present railroad facilities, and the strength of existing bridges and railroad structures it would be impossible to transport a gun of 160 tons weight by rail; to put into condition any of the transcontinental railroads to safely carry such a load would cost fully $20,000,000, and practically cause their reconstruction; if transported by water it could only be done, if at all, in times of peace, and would require expensive cranes, &c., to unload and deliver the same.

STATEMENT OF MR. SAMUEL R. WAITE.

BALTIMORE, MD., *November* 11, 1885.

The CHAIRMAN. Please state your name, residence, and your present position.

Mr. WAITE. Samuel R. Waite, Baltimore, Md. Member of the firm of Samuel R. Waite & Co.

The CHAIRMAN. What do you produce in your works?

Mr. WAITE. We are ship-builders; that is, we would willingly be ship-builders if we could get any ships to build, but you know what has been the condition of the ship-building industry in this country for the last ten or twelve years. There has been no demand for ships. Of course we bid for ships and build them if we get the contracts.

The CHAIRMAN. You have a ship-yard, then?

Mr. WAITE. Yes. Those [pointing to the wall] are models of merchant vessels we have built. We have been building one or two vessels of that class a year up to last year; but since then we have not built any. We built the steam propeller Chesapeake last year. We have never built an iron ship, but have built an iron steam-tug.

The CHAIRMAN. Are there any firms in Baltimore that have built iron ships?

Mr. WAITE. What do mean by a ship?

The CHAIRMAN. By ships the committee mean war ships, or vessels for the United States Government. They may be large vessels of 10,000 tons, or any size down to light-house tenders.

Mr. WAITE. There have been light-house tenders built here but no war ships have been built here since the war.

The CHAIRMAN. What is the largest iron or steel merchant ship that has been built in Baltimore?

Mr. WAITE. I think that the largest in tons was the ice-boat Latrobe, about a thousand tons.

The CHAIRMAN. Who built her?

Mr. WAITE. The hull was built by Malster & Co., at the Columbian Iron Works; the engines and boilers, by C. Reeder & Sons.

The CHAIRMAN. What is the present name of the former firm?

Mr. WAITE. It is now the Columbian Iron Works and Dry Dock Company, William T. Malster, president.

The CHAIRMAN. Has the Government any interest in the dry-dock belonging to the Columbian company?*

Mr. WAITE. When it granted the land the Government reserved the right to dock its vessels free of cost. It very seldom avails itself of the privilege, however. There may come a time when it will. It is open for the Government whenever it wants it. But the most of the Government work is done by contract after bidding, and outside parties have in many instances been able to bid upon and do the work cheaper, including the docking, than the dock will do the work, and not charge for the docking.

The CHAIRMAN. In every respect, except that right of the Government, then, this dock belongs to the Columbian Dock Company?

Mr. WAITE. Yes; it is chartered from the Baltimore Dry-Dock Company by the Columbian company, subject to this right of the Govern-

* See page 367.

ment to dock its ships free, which is the only hold the Government has on it.

The CHAIRMAN. With the exception of that dry-dock has this corporation in question, the Columbian Iron Works, any better facilities, in your opinion, than other firms here for building ships?

Mr. WAITE. They may have a tool more or less than the others, but in my opinion there are other people in this city who are just as capable of producing good work as that company, and having a capacity equal to that company.

The CHAIRMAN. Could the people to whom you refer build a 6,000-ton ship for the Government as cheaply and as well?

Mr. WAITE. Yes; because none of them have the facilities for building a 6,000-ton ship for the Government. We would all have to make preparation for it; but from my experience and observation I do not think the preparation needed would be immense. It would be a simple thing to build the hull. Of course to prepare to build the whole ship—engines, boilers, and all—would require a very extensive plant, but if you have already an established machine plant there is, comparatively speaking, not much of a plant required to build an iron ship; I say *comparatively* not much.

The CHAIRMAN. Have you ever built any engines or boilers?

Mr. WAITE. No; we do not build engines and boilers.

The CHAIRMAN. Have you at any time been requested by any Government to supply engines or boilers for ships?

Mr. WAITE. No.

The CHAIRMAN. Have you had requests for ships?

Mr. WAITE. No, but we have made bids for Government vessels.

The CHAIRMAN. Did you get any of the contracts?

Mr. WAITE. We have never built a Government vessel. We have repaired vessels for the Revenue Marine, but there have been no United States naval vessels that needed or asked for repairs in this port.

The CHAIRMAN. You may remember that in 1882 there were public advertisements asking all reputable manufacturers of vessels, steam engines, boilers, &c., having regular establishments, to submit plans, models, and designs to the Naval Advisory Board.

Mr. WAITE. Yes; I remember that.

The CHAIRMAN. Did you submit any models or plans to said Board?

Mr. WAITE. We did not.

The CHAIRMAN. Had you any particular reason for not doing so?

Mr. WAITE. No, sir; I cannot say that we had any special reason for not doing it, except that we did not feel the interest in the matter which we might have felt. There is one thing we might say, and that is, the conditions of the contracts were rather severe. Requiring a deposit of certified checks or bonds cannot be claimed to be a bad business idea. It is right when you come to a strict interpretation of business; but at the same time it was a feature in those contracts which would shut out competition, and it was considered by builders and others rather severe that such large deposits were required; whereas, in the opinion of the people, it could be covered by the usual methods of giving security, adopted by the Government in other contracts. For instance, when we have made bids to repair a vessel they required a bond which must be approved by Government officials, guaranteeing a faithful performance of the contract. It might be reasonable to go farther than that, but the amounts required to be deposited were very large, and, undoubtedly, had the effect of keeping out competition. They were not

only sureties, but large amounts in certified checks or Government bonds were required to be deposited before bids could be considered. It might have been considered a very good business idea, but it was very severe on those who wished to make bids.

The CHAIRMAN. Did you receive, in 1883, a circular letter asking advice and suggestions concerning designs of vessels for which Congress was called upon to make an appropriation?

Mr. WAITE. I think we did; but I do not remember now the exact character of it.

The CHAIRMAN. The object of sending out that circular was to learn from the intelligent men of the country what the defects were.

Mr. WAITE. I remember we talked it over, and we said at the time that it seemed strange the Government should fall into errors, with the able men they had.

The CHAIRMAN. Did you inform the Government of any of the conclusions you reached?

Mr. WAITE. No, sir; in fact we were not discussing that subject formally. It came up in conversation with some marine architects who were in the office at the time.

The CHAIRMAN. Have you ever made any machine tools in your works?

Mr. WAITE. No, sir. Our principal business is the building of wooden hulls; although in connection with engine builders we have made, and are prepared to make, bids for the construction of vessels ready for service, including everything.

The CHAIRMAN. Do you consider that Philadelphia, or any other place on the Delaware, or New York has any advantages over Baltimore in the construction of ships?

Mr. WAITE. I think Baltimore has the advantages. I think the labor in Baltimore is more conservative outside of the ship carpenters. If it comes to building iron ships I think Baltimore is the best point. As there is less of that class of labor employed here, there is less labor organization. At the same time there is ample labor. Iron ship-building does not require very much skilled labor. There must be some first-class foremen and first-class gang leaders.

The CHAIRMAN. Would you select foreigners for those foremen and leaders?

Mr. WAITE. I do not think the nationality would make any difference. It would depend upon the experience and capacity of the man and not his nationality.

The CHAIRMAN. If you received a contract from the Government to-morrow to build a 6,000 or 10,000 ton ship would the foremen or leading men in your shops be mostly Americans or foreigners?

Mr. WAITE. I should answer Americans; although the foreman in my shipwright shop now is a German-American, and some of my other foremen are Germans. But we taught them everything they know in this country.

The CHAIRMAN. Do you know anything about the forging or rolling-mill capacity of works in the United States?

Mr. WAITE. I do not.

The CHAIRMAN. By what method do you think the Government can best be supplied with guns, armor, and war vessels? That, of course, would include a consideration of the question whether the ships should be built entirely in the navy-yards, entirely in private yards, or partly in navy-yards and partly in private yards.

Mr. WAITE. I answer that question unhesitatingly, by private

parties—especially in point of economy; and, besides, I believe it could be done better. I only speak now of ships and not of making guns. I do not know anything about that and can say nothing about it.

The CHAIRMAN. What do you consider the comparative cost of building ships in navy-yards or in private yards?

Mr. WAITE. If that means what percentage can be saved, I believe that a very large percentage could be saved by awarding contracts to private firms.

The CHAIRMAN. Why cannot ships be built as cheaply in navy-yards as in private ones?

Mr. WAITE. I believe that the men are required to do more work in a day for private parties than for the Government.

The CHAIRMAN. Then you consider the eight-hour law a great disadvantage to the Government?

Mr. WAITE. Not that only; but I know that the men do not have to do as much work. We never take a man from a Government yard. He is spoiled for hard work. There is not the push in a Government yard that there is in a private one. The work can be done as well, but the private firms do not take so much time.

The CHAIRMAN. You say you are not acquainted with the forging and rolling-mill capacity of the country. Have you given any attention to the question whether a large iron-clad, similar to those of England, could be built in this country within a reasonable time? Such an iron-clad would require heavy steel forgings and armor plating.

Mr. WAITE. I cannot say positively, of course; but I know that there is nothing in the iron and steel line which our steel men will not undertake. If they have not the rolls and plant now they could get them. But there is no forging done in Baltimore to speak of.

The CHAIRMAN. Would you be willing to undertake the building of armored ships that would be duplicates of the latest types in the British navy?

Mr. WAITE. My impression is, yes.

The CHAIRMAN. Where would you get the heavy armor plates and steel shafts that would be required?

Mr. WAITE. We would have to prepare for them. I do not believe there is an establishment in the United States that could make them at once. They would want the Government to give them inducements.

The CHAIRMAN. What kind of inducements—subsidies or contracts?

Mr. WAITE. I mean good pay for the finished product, taking into consideration the expense of preparing the plant.

The CHAIRMAN. Are you familiar with the conclusions and recommendations of the Gun Foundry Board, which made a report February 16, 1884, and a supplementary report December 20, 1884?

Mr. WAITE. No, sir; I am not.

The CHAIRMAN. Some of their conclusions in regard to gun-making might be applied to ship-building?

Mr. WAITE. The heavy armor plating and heavy shafts are the only complications in building the ships in this country, and they are not in the way, except that nobody has ever been paid to produce them. My impression is that it is only necessary to order them to have them.

The CHAIRMAN. But that they must be ordered in sufficiently large quantities to pay for producing them?

Mr. WAITE. Yes, sir. So far as the raw material is concerned there is no scarcity of it. It is only necessary to have the tools; we have the skill and ability.

The CHAIRMAN. Do you think that such a ship could be built, if you had the plant, in this country as cheaply as in England?

Mr. WAITE. Not while there is the present difference in price of labor between the two countries.

The CHAIRMAN. Would the only difference be that of labor?

Mr. WAITE. Yes, sir; except the extra amount of cost which would be necessary to start the plant. After the first two ships, my judgment is that they would be better ships, and the superior workmanship here would nearly make up the difference in the cost of labor. No foreign work compares with our work in this country. We have merchant ships here which will compare with any in the world.

The CHAIRMAN. With your knowledge of ship-builders in Baltimore can you give the names of those firms which would be likely to undertake the building of iron and steel ships for the Government if they had sufficient inducements? Are there many or few?

Mr. WAITE. Very few. There are ten leading firms in the ship-building business in Baltimore, and I do not think that one of them has built what you would call a *ship*. There is no establishment in Baltimore that, without preparation, could jump at once to the building of a 6,000-ton ship.

The CHAIRMAN. How long would it take them to get ready.

Mr. WAITE. If a firm had a contract for a vessel and the material was available, they could get ready to build her while they were getting the preliminary parts of the vessel under way. It might take them several months.

The CHAIRMAN. I infer from your last statement that a very large amount of preparation is not necessary in order to build large iron or steel ships?

Mr. WAITE. That is to build the *hull* of an iron or steel ship. Of course, preparations are necessary for that, but nothing compared with the preparations necessary to build the boilers and engines.

The CHAIRMAN. Which system would you favor, that the ship-builder should finish the ship completely himself, or that he should have the right to buy the engines and boilers where he chooses?

Mr. WAITE. I think the only care the Government has is to get a ship, and it ought to make no difference whether one man builds the hull and another the engines, or whether one man builds all. It is decidedly better, in my opinion, that one man should have the *contract* for all. I do not think it is the best plan to make a contract with A for an engine and with B for a hull. I think one man should have the contract, and be responsible for all.

The CHAIRMAN. Have you any other suggestions to offer that will assist the committee in the direction of the resolution under which it is making its inquiries?

Mr. WAITE. Where we are deficient in producing 10,000-ton ships is in the need of heavy shafts, heavy forging, and plating. In order to encourage the production of these items (which are not available in the United States on account of the absence of proper plant to produce them) it will be necessary for the Government to give greater encouragement than by simply awarding contracts to the lowest bidders. There must be some understanding with the manufacturer which will encourage him—some subsidy, a liberal contract, or some line or discretion given to the Government officer to arrange for a start, after which the want will correct itself.

LETTER FROM ROBERT WETHERILL & CO.

[Robert Wetherill & Co., Corliss engine builders, boilers, shafting, pulleys, and mill-gearing.]

CHESTER, Pa., *August* 4, 1884.

GENTLEMEN: We notice the resolutions adopted by the Senate of the United States for the manufacture of heavy ordnance. We have located here, on the Philadelphia, Wilmington and Baltimore Railroad, large machine-shops, fitted up with the latest improved machine tools, and other facilities for the manufacture of heavy work. We also have near at hand a new open-hearth steel plant, where we can furnish solid steel castings.

We will be very much pleased to have you visit our works, and we will be at your service.

Respectfully, yours,

ROBERT WETHERILL & CO.

To the Select Committee, &c.

STATEMENT OF MR. B. B. HOTCHKISS.

NEW YORK, *August* 8, 1884.

The CHAIRMAN. The scope of our inquiry covers the production of steel—beginning, if you choose, at the ore—suitable for heavy guns, the armor-plating of ships, &c. One point covered in the resolution under which the committee acts is the extent to which we can get work done by, and the extent, if any, to which we can co-operate with, private parties. That is the main point, and is one on which your experience eminently qualifies you to speak.

Mr. HOTCHKISS. In regard to the different kinds of steel, there is but one that I use, namely, the Whitworth fluid compressed steel. I have been using it about nine years. At first I used Firth's; then an Austrian steel called Myer's, which was better than Firth's. Afterwards I began using Whitworth's, and the French navy department was so well pleased with it that they required in all contracts for steel gun-barrels that Whitworth's fluid compressed steel should be used.* Within the last few years they have had me experiment with Schneider's steel, made at Creusot, but I found the difference between the two steels was so great that we stand by Whitworth's. I know Sir Joseph Whitworth intimately now, but I never saw him until I had used his steel two years. I have *never* had any trouble with it.

The CHAIRMAN. Are you familiar with the process of manufacturing this steel?

Mr. HOTCHKISS. All I know is that it is fluid compressed. They will not allow us to see any of the processes of its manufacture. The members of the Gun Foundry Board are the only persons who have ever been admitted to the Whitworth works to witness the operations of liquid compression and hydraulic forging. Not one English officer has ever seen them. I have not.

The CHAIRMAN. What do you consider the peculiar excellence of the steel?

Mr. HOTCHKISS. Probably there is something in the mixture of the ore and iron which he uses. But the principal point is the fluid compression. He pours the steel into molds, and, when in its hottest state, brings hydraulic pressure to bear on the column. By that means the gas and what would make flaws in an ordinary bar of steel are pressed out of it. I have used about 10,000 bars of this steel, and have never had but one single bar to return, and that had a piece of cinder in it. The drill struck against the cinder, and of course had to stop.

The CHAIRMAN. In what shape does the steel come to you?

Mr. HOTCHKISS. In regular bars.

The CHAIRMAN. Do you work it over?

Mr. HOTCHKISS. Not at all. Some of the bars are oil tempered and some are not. The oil-tempered bars are for the larger guns.

The CHAIRMAN. Are they all of uniform excellence?

Mr. HOTCHKISS. Yes, sir; they are all very uniform.

Mr. HISCOCK. Your idea is that an ingot of steel from Whitworth,

* Whitworth has furnished about 20,000 gun-barrels for Hotchkiss guns. August 2, 1885. (Chairman).

of whatever size, is a fine quality of steel and free from gas-holes all the way through?

Mr. HOTCHKISS. He gives a guarantee to everybody that if there is so much as a pin-hole in an ingot it can be returned.

Mr. RANDALL. Will it heat and cool with uniformity?

Mr. HOTCHKISS. I have not seen any do better.

Mr. BUTLER. Are they not hammered at all?

Mr. HOTCHKISS. No, sir; they are forged by hydraulic pressure instead of by the hammer. The heated bars are handled between the dies, which open and close rapidly. The effect is a pressure, and not a blow. The temperature is about the same as that for the hammer.

The CHAIRMAN. Does it come from that process directly to you?

Mr. HOTCHKISS. Yes, sir; after cutting off the ends of the bars. We receive it as bar steel, and work it into guns.

Mr. BUTLER. You never tried any American steel?

Mr. HOTCHKISS. Never. Undoubtedly, however, you can make good steel here.

The whole foundation of the gun business is in the metal. There is no question about it. You must have good metal to make good guns. Of course there are a great many modes of making guns. Then, again, you must expect to see progress in their manufacture. Guns that are good to-day may be worthless ten years from now. Guns that were good twenty years ago are now of no use except for old metal.

The CHAIRMAN. You would not sell any of your own guns made twenty years ago?

Mr. HOTCHKISS. Not one. If you are going to meet a Government equipped with modern artillery you must have modern guns. If you take an old machine-shop and one built to-day, and undertake to get the same work out of both you will find that it cannot be done.

Mr. RANDALL. Do you have to compete in France with any Government establishment?

Mr. HOTCHKISS. No, sir; my guns are my inventions, and no Governments have attempted to copy them.

Mr. RANDALL. It is the policy of the French Government to encourage the enterprise of private individuals?

Mr. HOTCHKISS. Yes, sir.

Mr. RANDALL. Is there any disadvantage in selling to the Government in France?

Mr. HOTCHKISS. No, sir; there is no trouble about pay. I get my money always in twenty days.

Mr. RANDALL. I do not mean that. I refer to the amount of pay.

Mr. HOTCHKISS. We never have any trouble about that.

Mr. BUTLER. Do you use the Whitworth steel exclusively?

Mr. HOTCHKISS. No, sir; General Dard has made us experiment with the Schneider steel, and we have been doing so for about a year and a half. He said that, in case of trouble with England, France must be independent and make her own steel. So we have used about three or four hundred bars; but the difference between the two is very great. Messrs. Schneider & Co. replace all bars that do not meet the tests.

Mr. BUTLER. Where do the Schneider works get their ores?

Mr. HOTCHKISS. From different localities.

Mr. RANDALL. What is the policy of the German Government in regard to manufacturing guns. Have they Government works?

* The committee have been informed by Hotchkiss & Co., under date of November, 1885, that they use Schneider steel quite extensively, and that it possesses the high standard qualities required for gun manufacture. (Chairman.)

Mr. HOTCHKISS. No; none at all. All their guns are made by Krupp, and at Creusot. If any one should go to Germany and want to inspect the gun-works, the Government officials give him a letter to Krupp, who will ask him at once if he wants to buy guns. Mr. Krupp will show him the completed guns, but will never let him inspect the process of manufacture.

Mr. RANDALL. But what is the policy of the Government there?

Mr. HOTCHKISS. To encourage private enterprise.

Mr. RANDALL. How is it in England?

Mr. HOTCHKISS. There it is mixed. Most of the English guns are made by Armstrong. His establishment has been enlarged enormously.

Mr. HISCOCK. That is the old establishment the Government furnished the money for many years ago?

Mr. HOTCHKISS. Yes. England has just abandoned the old wrought-iron, and adopted the steel gun, and is now converting the old plant at Woolwich for the manufacture of steel guns. I have just closed a contract with the English Government for one hundred guns, part for the navy and part for the army.

Mr. RANDALL. Of what size?

Mr. HOTCHKISS. Six-pounder shell guns, made to fire from the shoulder, on board ship or in fortifications. I am preparing to build a factory in England.* The English Government notified me that it wanted 2,000 guns, at least.

The CHAIRMAN. Six pounders?

Mr. HOTCHKISS. Yes.

Mr. BUTLER. Does this gun move on a pivot?

Mr. HOTCHKISS. Yes; and is fired from the shoulder.

DESCRIPTION OF HOTCHKISS RAPID-FIRING NON-RECOIL GUN. (PLATE 4.)

This system of ordnance, called forth through the desire of some Governments for very powerful rapid-firing single-barrel guns, but much lighter than the revolving cannon, or other multibarrel gun which could be constructed of equal power, is practical for most light armaments.

Evidently the rapidity of fire of any single-barrel gun must fall far short of that of a gun with several barrels; however, a rapidity of about 15 or 20 rounds per minute has been attained, and this is considered sufficient for the purposes for which these guns are designed.

The Hotchkiss guns are called "non-recoil," because they are generally mounted on fixed elastic pivots and have no perceptible recoil, although the guns in reality have a definite amount of movement at the departure of the projectile sufficient to relieve the mountings of undue shock.

In all cases, except for the larger calibers for boat service, and for the field, these guns are laid by means of a stock or shoulder-piece, bearing against the left shoulder (as in the Hotchkiss revolving cannon), and a pistol-grip with trigger, which the gunner grasps with his right hand; he fires by pulling the trigger the moment his sights bear upon the object aimed at. It will be seen that this gun has the general characteristics of the Hotchkiss mounting, viz:

First. Gun mounted on a pivot and trained direct by the shoulder without the aid of any elevating or directing mechanism, thus enabling the gun to be pointed easily and rapidly from moving and rolling vessels against swiftly-running objects.

Second. Sighting and firing placed in the hand of a single man, which gives more accurate work; better results can be obtained than with any combination of men to sight and fire.

Mr. BUTLER. What is its range?

Mr. HOTCHKISS. Seven or eight thousand yards.

The CHAIRMAN. How long is the cartridge?

Mr. HOTCHKISS. The shells are 7 inches long, and the complete cartridges about 20½ inches.

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* Since the death of Mr. Hotchkiss, Armstrong & Co. have undertaken the manufacture of Hotchkiss guns, and the steel is furnished by Whitworth and others. (Chairman.)

The CHAIRMAN. What is the velocity of the projectile?

Mr. HOTCHKISS. It has a velocity of about 2,200 feet per second.

The CHAIRMAN. What is the length of the barrel?

Mr. HOTCHKISS. About 8 feet. The French war-vessels each carry from 20 to 32 of these guns; keeping a few extra ones in case of accident. They have a large number of sockets that the guns may be moved from one end of the ship to the other, or from one side to the other, at will. We have furnished the French navy department about 1,100 guns. The War Department has had 600 for flank defenses of fortifications; and we have a large number of orders on hand.

Mr. BUTLER. Can you use them for field pieces?

Mr. HOTCHKISS. Yes; very successfully.

The CHAIRMAN. Does the French Government make any large guns?

Mr. HOTCHKISS The army makes siege guns. My impression is that about the largest army-made gun is a 7-inch siege gun. All the sea-coast fortifications and all the ships are armed by the navy.

The CHAIRMAN. Who makes their guns?

Mr. HOTCHKISS. The material is principally supplied by Schneider & Co., of Le Creusot, and the naval gun factories make the guns.

The CHAIRMAN. How near Paris is your establishment?

Mr. HOTCHKISS. About 6 miles from Paris, at Saint-Denis. I have another at Magdeburg. 20 miles from Berlin, and am preparing to build one for the English. The Russians also want me to build one in Russia.

Mr. MORGAN. Would you come to the United States and build one here?

Mr. HOTCHKISS. Certainly, if the business was sufficient. Of course I cannot make guns as cheaply here as I can in France.

Mr. RANDALL. Why not?

Mr. HOTCHKISS. Because labor in France is so much cheaper. The highest price we pay for labor is seven francs a day—about $1.40.

Mr. RANDALL. What would be the price of corresponding labor here?

Mr. HOTCHKISS. I suppose about $3. You must remember that the cost of steel is in proportion to the labor upon it.

The CHAIRMAN. How long have you been in France?

Mr. HOTCHKISS. Seventeen years last June.

The CHAIRMAN. How many men do you employ?

Mr. HOTCHKISS. About a thousand.

The CHAIRMAN. How many styles of guns do you make?

Mr. HOTCHKISS. Three or four styles, but a great many different sizes and classes of guns. We make five sizes of revolving cannon.

The CHAIRMAN. Running from what caliber?

Mr. HOTCHKISS. From 1½ inches up to 2¼ inches. We have seven different guns, with projectiles ranging from a pound and a quarter up to six pounds.

The CHAIRMAN. How many men do you employ at Magdeburg?

Mr. HOTCHKISS. About 400.

Mr. RANDALL. When the French Government makes a contract for the delivery of large guns, how many do they test before they begin to accept?

Mr. HOTCHKISS. When a new and improved gun is presented, it is tested, and if the report is favorable, the contract is awarded. One-third of the money is paid when the contract is signed; one-third when the work is half done, and the remaining one-third when the contract is completed.

Mr. RANDALL. So that they practically advance the money to make these guns?

Mr. HOTCHKISS. Yes; all European Governments do the same. But I never receive pay in advance from the United States or France; but from the other Governments I usually take the advance.

Mr. RANDALL. What other Governments pay in advance?

Mr. HOTCHKISS. Krupp always gets an advance. He is at work for the whole world except the United States, and the German Government gets the benefit of the tests of all the guns that are manufactured. The German Government keeps an officer at Krupp's factory who sees every gun for every Government.

Mr. RANDALL. Is every gun fired before it is accepted?

Mr. HOTCHKISS. Yes; with an increased weight of projectile and an increased charge of powder, I think six rounds.

Mr. RANDALL. And the Government is not bound to take anything that does not come up to a previously agreed test?

Mr. HOTCHKISS. No, sir.

Mr. RANDALL. Each gun is tested, not each kind of gun?

Mr. HOTCHKISS. Every gun is accepted and received by itself.

Mr. MORGAN. About how many guns do you make a year?

Mr. HOTCHKISS. About four or five hundred. Each barrel has to be tested before and after it goes into the gun. I have never had a gun rejected.

Mr. MORGAN. What is the rough cost of your plant?

Mr. HOTCHKISS. I could not tell you. I commenced with a small plant, employing 20 men; now I employ 1,000. I have been all the time making additions. I have spent a large amount of money, and to tell how much, must refer to books. I never asked the Government to advance me a dollar.

The CHAIRMAN. Where were you born?

Mr. HOTCHKISS. In Sharon, Connecticut. I am 56 years old. I began life in the manufacture of hardware, and working on a farm.

The CHAIRMAN. Gentlemen, do you wish to ask Mr. Hotchkiss anything further?

Mr. RANDALL. What is the quick firing of what might be termed a battle test. Is it the rapidity of firing in battle? Do they ever make such a test?

Mr. HOTCHKISS. With the revolving cannon they fire 80 shots a minute.

Mr. RANDALL. Is that the character of all tests?

Mr. HOTCHKISS. As a rule not. They generally fire a number of rounds. Suppose you are firing at 1,500 yards; you would fire about 12 shots a minute, because you have to sight the gun at each shot. If you are at close quarters—200 or 300 yards—you could fire 20 shots a minute. Everything depends upon the distance. With a Gatling gun you can get an enormous speed, but at long ranges more time is necessary for good work.

The CHAIRMAN. What is the size of the smallest projectile?

Mr. HOTCHKISS. One and a half inches in diameter.

The CHAIRMAN. That has great force at a mile?

Mr. HOTCHKISS. Yes, up to five miles.

The CHAIRMAN. But I mean for good firing.

Mr. HOTCHKISS. The French Government have the guns sighted for 3,000 meters; that is about two miles.

SOUTH BOSTON IRON WORKS.

STATEMENT OF MR. WILLIAM P. HUNT.

NEWPORT, R. I., *August* 28, 1884.

The CHAIRMAN. Please give your full name and present position.

Mr. HUNT. William P. Hunt, president and treasurer of the South Boston Iron Works.

The CHAIRMAN. What is the extent of your experience in your profession?

Mr. HUNT. I have occupied an official position with the original South Boston Iron Company; and with the South Boston Iron Works since 1863, and have been connected with them since 1847.

The CHAIRMAN. Do you make yourself personally familiar with the processes of manufacture in your works?

Mr. HUNT. Yes, sir.

The CHAIRMAN. You have read the resolution under which we are acting?

Mr. HUNT. I have.

The CHAIRMAN. We would be glad to hear your opinion on the questions involved in our inquiry.

Mr. HUNT. I do not recall the exact language of the circular which the committee sent me, but I have understood that the two points which are being considered more especially, are the question as to the proper material for heavy ordnance and the question as to the proper plants for manufacturing large guns.

The CHAIRMAN. The general scope of the inquiry includes the capacity for the production of steel in this country, the extent to which heavy plants are held by private parties, the processes of manufacture, and the wisdom and extent of co-operation between the Government and private parties.

Mr. HUNT. As to the plants, I suppose you all know that ever since the establishment of the Government it has relied principally on four establishments for its supply of ordnance—the Tredegar Iron Works at Richmond, Va., the Fort Pitt Foundry at Pittsburgh, Pa., the West Point Foundry at Cold Spring, N. Y., and the South Boston Iron Works at Boston, Mass. Those establishments were supported regularly; that is, annual appropriations to a moderate amount were made, so that they were kept busy up to the time of the war and during the war. Appropriations were made without intermission during that time. Since the war very little has been done, and for a portion of the time nothing at all.

When the war broke out the Tredegar Works at Richmond of course served the South, and the others were very active in the North; during the war there were several other establishments that undertook to make, and did make, guns. The Scott Foundry at Reading, Pa., made a few, the Builders' Foundry in Providence made a few, a concern in Portland, Me., made a few; and there may have been others.

Up to the time of the war the Government had relied entirely upon those four establishments, and it is generally admitted that the ord-

nance at that time was excellent. It is even claimed that it was superior to ordnance in other parts of the world. I think we had heavier guns at the time the war broke out than any other nation. We then had 12-inch Columbiads, as we call them. As soon as the war broke out we increased the caliber to 15 inches, and some 200 15-inch guns were made; at that time they were considered of suitable proportions, but since the improvement in gunpowder they are found not to burn powder enough. They are only 11 calibers long, whereas they should be 28 or 30 calibers. But since the war there has been nothing asked for by the Government, consequently there has been no advance at all.

The CHAIRMAN. Please explain the difference between a long gun and a short gun with respect to the advantages possessed by the long one.

Mr. HUNT. The trial to a gun is in overcoming the inertia of the projectile. Formerly quick-burning powder was used, and the gun was made comparatively short because the powder had spent its force by the time the projectile had been thrown ten or twelve times its diameter. It is now found that better results are attained by using "slow-burning" powder, which starts the inert projectile gradually and without severe strain upon the gun, but increases its force for twice the length of time of quick-burning powder. Consequently the gun should be twice as long in order to hold and avail of this force. The result is much relief to the gun in overcoming the inertia of the projectile, and much higher muzzle velocity, from the longer time the projectile is in the hands of the powder, so to speak. Dynamite in a gun would break the gun, because the inertia of the projectile would not be overcome so suddenly without more strain than the gun would bear. Thus it appears that improved gunpowder with guns of proper length not only increases the velocity of the projectile, but does so with much less stress upon the gun, adding immensely to the reliability and endurance. The data from which to estimate the practical value of this more serviceable gunpowder, unfortunately, are very meager. In this country very little experimental firing has taken place within the last fifteen years, but with what experience we have had, certainly there is no evidence to detract from a position of great importance.

We now have in process of construction three 12-inch rifles of about 50 tons weight each, one 12-inch rifle mortar about 13 tons weight, and one 10-inch rifle about 38 tons weight. These guns are all of differing types, and the material is mainly cast iron. When these guns are completed, a good opportunity will be had to test the practical value of the improved powder to this country. It may turn out, as I believe it will, that all these guns will endure sufficiently heavy charges to develop the same energy that is obtained from guns of the same caliber in Europe. My confidence is not without some evidence to sustain it. Some two hundred and fifty cast-iron guns have been converted into 8-inch rifles. All have been fired with proof charges, and many with battering charges. None have failed, although as completed they are of lighter weight than the 8-inch rifle of the English service. The 15-inch smooth-bore Rodman gun has been fired one hundred rounds with all the powder that could be burned in it (130 pounds), giving a muzzle velocity of 1,700 feet per second—equivalent to the penetration of ten (10) inches plate-iron at a distance of half a mile—and with a pressure upon the bore much less than it would safely bear.

Mr. BUTLER. Have not some of these guns had steel tubes put in them?

Mr. HUNT. Yes, and afterwards coiled and iron tubes were adopted, but there were difficulties with these. They had a long space to be

welded, and some of the guns have proved defective on account of the tubes showing unsoundness of weld. There is a difference of opinion among officers whether or not the coiled tube strengthens the gun. Some are quite positive that the coiled tube adds very much to its strength. My belief is that it does not, and the reason is this: As we all know, wrought iron will yield at a strain of 25,000 pounds to the square inch, whereas cast iron will endure more than that, and my idea is that the tube is crowded back against the cast iron when the gun is fired, and relies on the cast iron to strengthen it up. We know that cast iron is equal to a strain of 25,000 pounds to the square inch.

The CHAIRMAN. How many guns have you converted?

Mr. HUNT. We have converted more than one hundred.

The CHAIRMAN. Did you make guns of that character just before the war?

Mr. HUNT. We did not.

The CHAIRMAN. Were these conversions made of your own guns exclusively?

Mr. HUNT. No, sir; partly our own, and partly others.

The CHAIRMAN. Were they of uniform quality?

Mr. HUNT. Yes, sir; none were accepted unless they would stand a strain of 30,000 pounds to the square inch.

I do not know of any failure of the cast-iron guns we had when the war broke out. There have been none made since of any account. I do not know of any failure since we have used modern powder and projectiles. I think that proves a remarkable uniformity of the material. We have made a 12¼ or 12½ inch rifle, which has a tube in it; made in 1877, I think. That is the only cast-iron gun fired since that time which is new. That has been fired with charges up to 200 pounds of powder and something like 100 rounds, and it continues to be serviceable. It is only about eighteen calibers long. It is a cast gun, with a coiled tube.

The CHAIRMAN. Have you improved the material so that cast iron has more strength than before the war? Do you make a stronger gun?

Mr. HUNT. It is not materially stronger. We get it up to bearing a strain of 33,000 pounds to the square inch, which is a more safe strength than if it would stand 40,000. When you get a higher strength you necessarily get a more brittle metal. I think 33,000 pounds is sufficient. It has qualities like wrought iron.

The CHAIRMAN. Can you depend upon the uniformity of it?

Mr. HUNT. I feel very confident on that point. The statement I have made, that out of 250 guns not one failed, shows great uniformity. A great many old guns have been cut up, and generally we find no defect.

The CHAIRMAN. Do you not find any with gas holes or blow holes, as in steel?

Mr. HUNT. Not at all. I do not think it is right to call this metal cast iron, because it is quite different from iron made in ordinary foundries, which has a strength of only twelve or fifteen thousand pounds to the square inch. Such iron is generally defective and shrinks more or less. But it is quite another thing when treated as we treat it. We do not use it as soon as it is melted. We keep it in fusion for six hours. This purifies it and takes out a large proportion of the carbon, thus making it more like wrought iron. We keep it in the furnace until it approaches the nature of malleable iron, and then draw it off into a casting. In this way we increase the strength to 30,000 or 35,000 pounds to the square inch, and give it a more ductile character, such that a sample of it in a blacksmith's forge could be drawn down like wrought iron.

So that I do not think American gun metal should be classed as cast iron.

The CHAIRMAN. How does the rifling of cast-iron guns stand the firing? Do not the edges wear away faster than steel?

Mr. HUNT. Yes; they wear faster than steel; but I have examined the Parrott guns after long firing and never found the rifling worn away seriously.

The CHAIRMAN. I do not know how that was, but I do know that a great many of them burst.

Mr. HUNT. They used quick-burning powder and very bad projectiles, and the shrinking of the iron band or reinforce was probably too great in some cases, and too light in others; some in service showed wonderful endurance.

I think in the Parrott gun the abrupt line between the wrought-iron reinforce and the cast-iron gun was very great, more than it should have been. I do not think it is a well-proportioned gun at all. I think the failure of the Parrott gun was often owing to this cause; but we had enough, I think, that did good service to show what cast iron would do and to show that the rifling was durable.

The CHAIRMAN. I think General Gilmore published some sketches of the tests of these guns. There was a 30-pound Parrott put up at Fort Gregg and fired 4,700 times with great care. After each shot it was thoroughly washed out, and then every one would get out of the way when it was fired.

Mr. HUNT. I have seen Parrott guns very badly scored through the rifling; but that would occur in any gun.

Mr. MILLER. In my experience with Parrott guns—and I have had considerable—the trouble was that the projectiles were badly made. I found that out directly. They were not all of equal weight and were not gauged at all.

Mr. HUNT. If it is an objection to the cast-iron gun that the rifling wears faster, it could be remedied by having the bands wider and not cut so fine. That could be compensated for by having the heavier grooves not so many and so fine.

The CHAIRMAN. There is another subject we want to know something about. How large guns can you make? The determination seems to be at the present time to make the larger guns of steel and to build them up. How well can private parties undertake that work and what conveniences have they for it?

Mr. HUNT. We can make a steel built-up gun as large as any other, if we have the material to work with, that is, steel forgings. We can make a steel built-up gun as large as a cast-iron gun. We now have one of cast iron on the lathe (which weighed 100 tons in the rough), finished down to a 12-inch rifle. Its finished weight will be between 50 and 60 tons. But we have facilities for making at one casting a cast-iron gun of 120 tons, and we have lathes that will handle it.* We can machine-make a steel gun as well as an iron gun.

Mr. BUTLER. Where would you get the steel?

Mr. HUNT. At present it would have to be imported. But there is no difficulty about making it in this country if inducements were given to make as large forgings. It is a question whether the day of steam-hammers has not gone by. If there was not so much money invested in steam-hammers in Europe, the question would be simplified. In France there is such a large investment in those tools that they encourage the manufacture of steel forgings with heavy hammers.†

* See page 466.

† Hammers were built to meet the demand for steel forgings. (Chairman.)

Mr. BUTLER. If you received an order from the Government for fifty 12-inch steel guns, where would you get the material?

Mr. HUNT. We would have to import it. It could not be made in this country to-day. The heaviest forgings I think now can be made at Nashua. They have the most effective hammer in the country. They can make a 30,000 pounds' ingot and hammer it. Park Brothers, of Pittsburgh, have a nominally larger hammer, but I am informed it has not done as good work as the Nashua hammer.

Mr. BUTLER. Do you know if there are any large hydraulic presses in this country?

Mr. HUNT. I think not; I do not know of any. In Sweden they have made homogeneous guns—cast the same as we cast iron—and my belief is that the gun of the future will be a homogeneous cast gun. If the cast iron or the metal we now use proves to be unequal to the work called for, the improvement will be in that direction. There is no difficulty in making a cast-steel gun which will stand 60,000 pounds to the square inch. They do it in Sweden, and there is no reason why it cannot be done here. It will require considerable experimenting. I do not think you can go to work and cast a steel gun in this country now, and be likely to have it sound, but the improvement will be in that direction, and when we find that such guns as we are now making in Boston are not strong enough—which I do not believe we shall find very soon—but when we do, the improvement will be in making guns in a similar way of a stronger material.

The CHAIRMAN. In what form is your steel imported?

Mr. HUNT. As a steel forging. Several years ago I wrote to the Chief of Ordnance of the Navy that we were prepared to make steel guns of European standard and European prices if we could import the steel forgings.

The CHAIRMAN. I mean of what shape and size.

Mr. HUNT. Gun forgings would be the tube, which would be the full length and about half the weight of the finished gun; then a reinforce sleeve for the breech, called a jacket; and several reinforce rings, or "frets," as they are called; also the trunnion-ring.

The CHAIRMAN. What would *you* do, then, if the tube was imported made and the jackets were imported made?

Mr. HUNT. We should finish them up, assemble the parts, and complete the gun.

The CHAIRMAN. Then, it would be practically built abroad?

Mr. HUNT. Yes; the material would be made and forged abroad; but if we had large enough orders——

Mr. BUTLER. Pardon me. Assuming that the Government would give an order for a hundred 12-inch guns, and that we had the plant to get the heaviest forgings—as heavy as any in the world—is there material in this country out of which the best gun steel can be made?

Mr. HUNT. Certainly.

Mr. BUTLER. You have no doubt about that?

Mr. HUNT. No doubt of it at all.

Mr. BUTLER. You think we could get the ore to make the best steel in this country?

Mr. HUNT. No one would dispute that.

Mr. BUTLER. If that be true, why is it that the steel makers import ores from Algiers and Spain?

Mr. HUNT. Simply because we can get it on the coast cheaper than we can bring it from Lake Superior. You have in North Carolina as fine ore as any in the world.

Mr. BUTLER. As fine as Spanish?

Mr. HUNT. Yes. On the New River, in Virginia, there is an ore called red hematite, or New River ore, which is almost entirely free from phosphorus. We have a duplicate of the famous Dannemora ores of Sweden in New Hampshire, called Old Franconia ore, which has been worked for more than a hundred years.

The CHAIRMAN. What is the character of the Salisbury ore, Litchfield County, Connecticut?

Mr. HUNT. It is very superior. It is called brown hematite, and is used for making iron car wheels. It is not used for making steel.

The CHAIRMAN. They made guns there during the revolution.

Mr. HUNT. We use it now entirely for our iron guns.

Mr. BUTLER. You think, then, that in case of an emergency the Government could put its hand on the best ore in the world right here?

Mr. HUNT. There is no question about it.

Mr. MILLER. There is plenty of good ore on the Pacific coast.

The CHAIRMAN. Is there not some in Alabama?

Mr. HUNT. Alabama has a great abundance of rich hematite ore. I do not know about its properties for making steel, but I know that in Virginia, West Virginia, and North Carolina there is an abundance of ore suitable for producing steel.

The CHAIRMAN. We would like to have your opinion concerning this question: Would it be wise for the Government to contract with private parties with the understanding that they were to put up the most improved plant, and have the whole work done by them, or would it be wise for the Government to get these parts, such as you speak of, imported and have a great plant of its own?

Mr. HUNT. It is my opinion that it would be wise for the Government to rely upon private parties for its ordnance supplies, as it has done from the commencement of the Government down to the present time.

Investigation of the facts will show that this course has worked well in the past. The Government has been able to obtain all the material of this kind that was required, and at reasonable prices. At the same time progress in the improvement of ordnance continued regularly until at the time of the breaking out of the war (1861) American guns were heavier and of superior design to those of European nations. Since the war no encouragement has been given to induce the same parties or others to keep pace with other nations in the improvement of ordnance, and to this fact alone should our present inferior standing be chargeable.

On the other hand, it is my opinion that a Government establishment for the manufacture of ordnance would practically prove expensive and inefficient. European experience shows this. Disinterested and formal official management of such an establishment would be much less likely to develop progressive ideas than the watchfulness of private interest and ambition.

Another important reason why it would be for the public interest to develope a private rather than a Government establishment is the desirability of sharing with Germany and England the patronage from other nations who purchase their supplies of ordnance. Of course this could not be obtained without a first-class private establishment.

It is likely that the benefit to Germany from the foreign work turned out at the Krupp establishment would much more than compensate for the expense to the German Government in assisting to build up these extensive works.

The CHAIRMAN. The costly part of it is the preparing of these parts. It would require an expensive plant, heavy hammers, &c.

Mr. HUNT. The difficulty is to get steel forgings if you want steel guns You must show some steel manufacturers here that they will get business enough to warrant them in going into that business.

The CHAIRMAN. Have you ever calculated the cost of a plant to make these forgings for steel guns?

Mr. HUNT. Do you mean by the Whitworth process?

The CHAIRMAN. Yes.

Mr. HUNT. I have not. I do not know anything more than what I get by reports from others. In fact, no one but Whitworth has undertaken it. I think Firth & Sons are now making arrangements to put in the Whitworth system of forging, and no doubt others in England will do it.*

Mr. MILLER. That is fluid compressed steel?

Mr. HUNT. No. I have doubts whether that is found to be desirable; but they use compression in the soft state. After it changes into a pasty condition it is then compressed by hydraulic pressure. How expensive that would be, how practical it would be, and how near it would come to heavy forgings as made under hammers, I am not prepared to say.

Mr. MILLER. Have you calculated the cost of a plant necessary to make these forgings by hammers?

Mr. HUNT. It is a very expensive business to make forgings by hammers when you undertake these large guns, such as the forging for a hundred-ton gun. In order to get a thorough forging or hammering of it you must have such hammers as they use in France, costing nearly a million dollars.

Those hammers are very expensive, and I have understood that no Whitworth press has been made of a capacity equal to the hammers referred to. I do not think he has facilities for making large guns like that. I do not know whether that process can be applied to large guns.

Mr. MILLER. But it is much better if it can be?

Mr. HUNT. No doubt. There is no difficulty in finding machinery facilities in this country. The most expensive portion of the outfit will be the heavy lathes required.

Mr. BUTLER. If you got an order from the Government for one hundred 12-inch guns of steel, how long would it be before you could deliver them?

Mr. HUNT. I could not make a definite estimate. It would depend upon how long we should be held back to get the forgings. I suppose we could, with present facilities, two lathes, make seven or eight in a year.

Mr. BUTLER. It would take several years to deliver them all?

Mr. HUNT. Yes; but we could duplicate those lathes and produce them as rapidly as desired if we could get the forgings.

The CHAIRMAN. How long would it take to finish a lathe?

Mr. HUNT. Not less than a year.

Mr. BUTLER. Can you form any idea of how long it would require the different foundries of this country to prepare the forgings for those one hundred 12-inch guns, admitting we can make them in this country?

Mr. HUNT. I do not think you could get the first forging in a year. It would require more than a year to make the hammer.

Mr. BUTLER. Suppose you used the hydraulic press.

Mr. HUNT. I cannot say. I do not think a hydraulic press on so large a scale has ever been made.

Mr. MILLER. How large a gun has Whitworth ever made?

* See page 15.

MR. JAQUES. He has cast, and forged with his largest hydraulic forging-press, the parts for the largest guns that have ever been built—the Armstrong 100-ton guns.* The capacity of that press is equal to the forging capacity of the Creusot hammer.

Mr. HUNT. I was not aware of that. It is new to me.

Mr. MILLER. You have a theory that there can be a gun made of steel, cast the same as you cast iron, a gun that will have a strength equal to these forged guns?

Mr. HUNT. I do not say that, but a strength capable of bearing a strain of sixty to eighty thousand pounds to the square inch, which will be abundant strength for the use to which they would be put.

Mr. MILLER. How large castings have you made?

Mr. HUNT. Heavy steel rolls have been made in this country perhaps two feet and a half in diameter and eight feet long.

Mr. MILLER. Perfectly sound all the way through?

Mr. HUNT. Yes; I saw at the Norway works a casting which they guaranteed sound. I only express my opinion that the gun of the future will be a homogeneous cast gun, instead of a built-up gun. These guns we are making will be fired, and I am satisfied to abide the result.

Mr. MILLER. How long are they?

Mr. HUNT. Twenty-eight or twenty-nine calibers.

Mr. MILLER. How long are the converted guns?

Mr. HUNT. Very short. The eight-inch rifles are not more than half as long as they ought to be.

Mr. MILLER. What kind of heat do you use for your furnaces?

Mr. HUNT. We use bituminous coal for making guns.

Mr. MILLER. Nothing else.

Mr. HUNT. We have lately used petroleum, but not on guns.

Mr. BUTLER. How do you like the vapor fuel? Has the result of your experiments been satisfactory?

Mr. HUNT. Very satisfactory, indeed, for our work. My object in starting it was to avoid the difficulty we have in running our furnaces and keeping them heated. It is a good deal of a problem to have them all alike, and with coal fire you cannot regulate the heat as with vapor fuel. With vapor you can easily increase the heat or reduce it. That was my principal object. Another object of a good deal of importance is that I believe in vapor fuel we get rid of the sulphur, which we find in coal, and which injures iron.

Mr. BUTLER. You consider it a purer heat?

Mr. HUNT. Yes; it is the same as using charcoal instead of mineral coal.

Mr. BUTLER. Can you get as high a temperature as with coal?

Mr. HUNT. Higher.

Mr. BUTLER. Which is the more expensive?

Mr. HUNT. In our market it is more economical to use coal in the furnaces we have than vapor fuel; but I am ready to believe that vapor will be found to be cheaper in suitable furnaces. Oil in our market is higher than it ought to be compared with other markets. It is controlled by the Standard Oil Company.

Mr. BUTLER. Can you use the same furnace for it?

Mr. HUNT. I had to alter it, but did not make any material alteration. If I were to make a new furnace I should make it different for vapor fuel than for coal, and I think with proper furnaces vapor fuel will be found to be economical.

The CHAIRMAN. Have not these gentlemen who are availing themselves so largely now of natural gas an advantage over everybody else?

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* Whitworth has supplied all the tubes and a majority of the jackets and hoops to Armstrong & Co. for the fabrication of the 110-ton guns. See page 23. (W. H. J., August 2, 1885.)

Mr. HUNT. They have, undoubtedly. If we had natural gas we should be glad to use it. It is great economy.

The CHAIRMAN. I have no doubt that even if bituminous coal is used, it will be used in the shape of gas in the future.

Mr. BUTLER. Then it would not have that objection in the shape of sulphur.

Mr. HUNT. I think it would have. I am not enough of a chemist, however, to know if this sulphur would be retained in coal gas.

The CHAIRMAN. How about natural gas?

Captain SHALER. Hussey, Howe & Co., of Pittsburgh, think it is perfectly pure, and contains no sulphur. They think it comes from petroleum.

Mr. HUNT. It is an important question, the supply of petroleum. It may become even more abundant than now, or it may give out in localities and have to be brought from a distance.

The CHAIRMAN. What is the price of petroleum, per barrel?

Mr. HUNT. Three dollars a barrel in Boston.

Mr. MILLER. Eighty cents a barrel at the works.

Mr. HUNT. Gas is better in a great many ways. I know an establishment that uses it in making horseshoe nails—the Putnam Nail Company, of Boston—and they now make better nails than they ever made before. They have a secret process.

We find that with a heat of 600 degrees we can get a perfect vapor—no smoke at all. At first we thought it would require a much higher temperature, and have run it as high as 1,200 degrees. But that is not necessary. With 600 degrees it is converted into vapor. At 500 it will drip a little.

The CHAIRMAN. Then the summary of your opinion is, that the better way for the Government is to contract for the finished gun with private parties?

Mr. HUNT. I think so long as the Government has relied entirely upon private parties for its ordnance up to the war, and it certainly had very superior ordnance at that time, I do not think there is any need of changing the method of obtaining their supplies. The only reason they have not as good guns as Germany is because they stopped the supply. The advance would have continued here if appropriations had continued regularly.

The CHAIRMAN. Yes; we have not guns because we have not used them.

Mr. HUNT. That is it. I proposed some years ago to furnish steel guns at European prices; but I had no orders. At first we should have imported steel, but afterwards we would have made arrangements to make it here. If this Government had continued its appropriations since the war as before we should have had establishments in this country equal to those of Germany. Krupp's establishment has grown up since my connection with the South Boston Iron Works from 25 men to 20,000. The advantage to Germany has been more than ten times the cost.

Mr. MILLER. It seems that Krupp's establishment has built 150 heavy guns for China.

Mr. HUNT. They have had an immense amount of business for foreign Governments.

I want to emphasize one point, and that is, that I do not want it understood that there is no establishment in this country that can make steel guns; because we can. All we want is an order for them. As a matter of fact, we are now at work on eight steel guns, under contract with the Navy Department, for the armaments of the new cruisers.

LETTER FROM THE WEST POINT FOUNDRY.

COLD SPRING, N. Y., *August* 1, 1884.

GENTLEMEN: We beg leave to acknowledge the receipt of printed circular, dated July 16th, which came to hand yesterday.

We are not manufacturers of steel, and you will no doubt receive more accurate information than we could give from parties now engaged in the business.

In reply therefore to this part of your circular, we would merely state that we believe the Whitworth system of compressing liquid steel in the mold, and using hydraulic forging presses, instead of hammers, to be the best method of producing steel for ordnance purposes.

We could manufacture the presses and other work required for such a plant if we could procure the necessary drawings and specifications.

The part of the business which we are desirous of obtaining would be the manufacture of cannon from steel ingots, furnished by other parties and delivered to us for the purpose.

Our establishment in its present state is capable of finishing a small number of steel breech-loading guns in a year, but is entirely inadequate to the wants of the Government.

In case we were called upon to furnish guns in large numbers and with any degree of rapidity, we would propose to put up an entirely new plant on our property, independent of the old one.

The cost of such a plant, capaple of making 100 to 120 guns per year, ranging from 100 tons to 6 inches caliber, we have estimated approximately at $800,000.

We do not think it would be possible, however, to procure the capital, particularly in view of the uncertainty of the annual appropriation for ordnance.

If it is desired, therefore, to build it without delay, it seems necessary to us that the Government should advance the necessary funds to the manufacturer, under such conditions as would protect the interests of the United States, and with a proviso for the ultimate repayment of the money.

If liberal contracts were given, the manufacturer might gradually build up a suitable establishment, but this would take many years to accomplish, and we do not think capitalists could be induced to invest money in a project subject to so much uncertainty as regards the amount and character of the business to be received from the Government. As regards location, we think our establishment, which is situated on the Hudson River, 54 miles from New York, opposite West Point, is equal to any in the country. We have water communication to New York, and also railroad communication with all parts of the country.

Referring to the estimate of cost of gun-factory plant, given in your circular, we would say, in the absence of drawings and specifications of the machinery, that it is not possible for us to make an estimate to compare with that given by the Gun Foundry Board.

In conclusion, we would say that we will appear before your committee at any time you may appoint, and it would give us much pleasure if your committee would visit our establishment.

We may mention that we are now fabricating an 8-inch steel breech-loading gun of 12 tons for the War Department, from material furnished us.

The Navy Department has also accepted our proposition to construct from furnished materials five 6-inch and two 8-inch steel guns for the new vessels of war now building.

Very respectfully, your obedient servants,

WEST POINT FOUNDRY ASSOCIATION,
By G. PAULDING,
President.

To the Select Committee, &c.

STATEMENT OF GENERAL R. S. RIPLEY.

NEW YORK HOTEL, *September* 8, 1884.

To the Select Committee of the United States Senate on Ordnance and War Ships:

GENTLEMEN: I have received a copy of the circular signed by yourself, dated July 16, 1884. Besides asking for information on the estimates of the cost of establishing ordnance work, it also asks for anything relating to the subject which may be of use to the committee.

My connection with and knowledge of artillery is such that suggestions on general matters will probably be of more interest than details on estimates. These last must be sought for from steel masters and men practically engaged in the business, and appear to have been well collected and presented in the report of the Gun Foundry Board of February 16, 1884.

Since the war of secession the United States have neglected the matter to a degree, until at this time they are completely deficient in this element of defense, although it cannot be said that any power is fully prepared. Up to the period of the definite introduction of rifled cannon it was the admitted fact that the material for heavy ordnance used in the United States was the best in the world, namely, cold-blast charcoal iron made from the best selected American ores. This metal stood severer pressure and gave greater life to the gun than the heavy gun metal of any other nation. With the introduction of the many improvements in iron and steel metallurgy and the adoption of rifled ordnance many powers believed that they must use a material for guns of greater strength than cast iron. They were not long in setting about it, and commenced building expensive rifled ordnance on a large scale. Herr Krupp in Germany, and Sir William Armstrong and others in England, soon developed systems of ordnance, pressed them upon their respective Governments, and speedily introduced them throughout the world. The French followed, and their works very soon turned out guns of as great capacity and strength, while the smaller powers bought their weapons from the great factories of the larger states. The fortifications of the world have been filled up with British and German guns, with the result which we have lately seen.

There are a few things remarkable in this progress of ordnance during all these years. The contractors, seemingly intent on enlarging their contracts, pushed as rapidly as they could get material to stand the radial tension of large calibers, went in for enlarging the caliber of the gun. At the same time the iron and steel plate manufacturers were not idle, and amongst the lot there has been established in the greater countries about as efficacious a system of protection. The British ordnance authorities a few years since made a so-called Woolwich infant of 35 tons weight, and Herr Krupp immediately set out to beat it. The iron-platers were not behindhand, and so, after a series of costly exper-

iments, they went further, and an 80-ton gun was manufactured at Woolwich. Herr Krupp followed, and Sir William Armstrong built several 100-ton guns for the Italians. All these guns stand radial tension very well. Where they fail is in longitudinal tension, which ought to be less dangerous. Attention has not been given to what is really the essential element of the problem, namely, increasing to its maximum the velocity of the projectile with a minimum strain upon the piece. In the United States the subject has attracted some consideration. Endeavors were made to obtain high velocity through the Haskell multicharge gun. However the theory of this gun may have been correct, the attempt has not succeeded in practice, owing to various reasons, principally mechanical. Besides, even if the velocity were obtained, guns of this system would be impracticable for service. No artilleryman would want to load four or five times for one shot.

In Europe very successful results have been obtained with another system. A forged steel tube of 5 inches caliber was constructed at Terre Noire, near St. Etienne, and various experiments were made therewith during the summer of 1883. From them certain results were deduced, of which the first and most important is, that it is perfectly practicable to fire any desired amount of powder behind a projectile without undue strain to the gun, and safely to obtain the maximum practical velocity which a projectile can derive from gunpowder. This was effected by a novel method of firing the powder in a fixed cartridge, the gun being provided with a very long powder chamber. Closely approximative results of the relation of increased velocity to the increase of charge and pressure on the breech of the piece and base of the projectile were observed. With a charge equal to the weight of projectile a velocity of 757 meters, equal to 2,480 feet per second, was gained, while the pressure on the base of the cartridge was not excessive. It is probable that by using other powders and with some modification of the system, this velocity may be somewhat increased, but the indications are that in practice for high velocities the practical maximum charge will be about the weight of the projectile. Recurring to the subject of providing appliances for the construction of ordnance, I venture to make a few suggestions as they seem to be permitted by the terms of the circular. As to establish a plant for ordnance works is a work of time, it would be impossible to determine an absolutely accurate estimate of costs for various reasons. The subject of artillery, as before said, is progressive, and no model has been accepted for the Army service gun of different calibers. While, therefore, it seems the part of good policy to go on and establish the material part of the plant for a Government ordnance factory, without delay, the greater portion being necessary and available whatever the model, it appears that the experiments to enable the model for the service gun of the immediate future to be determined should be pushed with all possible rapidity, so that the manufacture of such guns may be vigorously commenced as soon as may be, either in private or Government establishments. This could be done by providing immediately two or more guns of large caliber, say 8 or 9 inches, provided with lengthened powder chambers as well as very long chases. As the guns would be purely for experimental purposes, they should be made of weight sufficient to insure strength of whatever material (preferably of steel) they would be made, and length enough for all necessary experiments. The length of the chase may vary in the different guns, and superfluity may be cut away when it is determined. The guns should be provided with a multiplicity of crusher gauges to

measure the longitudinal and radial pressures throughout the length of the guns, at the breech, at the base of the projectile, and at close intervals along the walls of the chamber, and in front of the seat of the projectile. The object of this very valuable experiment is to determine the maximum velocity attainable with the minimum strain upon the gun.

I have briefly indicated a few views which, as an old artillerist, have occurred to me in connection with the subject. Should it be desired, I can furnish them in a more extended form with details.

I am, very respectfully, your obedient servant,

R. S. RIPLEY.

STATEMENT OF MR. A. H. EMERY.

NEW YORK, *August* 8, 1884.

The CHAIRMAN. Please state your name and residence.

Mr. EMERY. A. H. Emery, of Stamford, Conn.

The CHAIRMAN. If there is no objection, Mr. Emery will proceed with his statements, making them as clear, concise, and compact as he can.

Mr. EMERY. There are some points I want to make first in regard to the difficulty we manufacturers labor under in dealing with our Government, especially in the matter of ordnance, where the Government is the only consumer in the country, and we have to sell to it or nobody, as no one wants to make a plant dependent solely on foreign customers, when our tariff averages, as it does on gun and similar material, about 40 per cent.

The natural desire of the ordnance officer to introduce and use his own ideas and inventions may exclude from trial and use the inventions of the civilian inventor and manufacturer; and the jealousies existing between the officers themselves may often prevent the Departments from making use of even the best inventions which are provided by their own officers.

Mr. RANDALL. What advantage would the Government officer get from the use of his invention?

Mr. EMERY. If it is used successfully, he has the pleasure and credit of such success. If at the same time his invention is patented, as was the case with the Rodman system of cast ordnance, he then has the profit resulting to him from the use of his patent.

Mr. RANDALL. How did Rodman use his invention?

Mr. EMERY. He sold it to Charles Knap, the owner of the Fort Pitt Foundry, who himself manufactured heavy ordnance under this patent, and who also sold rights to the West Point and South Boston foundries to manufacture under this patent. These manufactures paid a royalty, which was divided between Mr. Knap and General Rodman. But, fortunately in this case, the Government got the benefit of the use of a good invention. All of our 10 and 15 inch columbiads were made under this patent.

Mr. BUTLER. I did not exactly catch the point of your remarks illustrating the difficulties which inventors and civilians have in dealing with the Government. In what respect does this illustrate that?

Mr. EMERY. During the war I had to go to the Chief of Ordnance of the Navy, and he had authority to use my inventions or his own, as he preferred. This difficulty pertains especially to ordnance and projectiles which no one here but the Government buys.

Mr. HISCOCK. You mean that they have their own inventions, and want no others?

Mr. EMERY. Yes, sir. * * * * *

In order to determine the kind of tools requisite to the production of the best guns, we may consider briefly the difficulties of making the different classes of guns that are to-day used in the world.

This [exhibiting a drawing to the committee] is a drawing of an Eng-

lish 12-inch rifle. This inner portion is the steel tube, or main barrel of the gun, surrounded by these wrought-iron bands.

Until comparatively recently this barrel was made of coiled wrought iron welded into a tube, as the bands now are; but the English officers have now fully concluded that these bands of wrought iron should be replaced by steel in some form.

Let me remark that steel cast and not reworked may have properties which are very much better than cast iron, but that every bit of working by the hammer or press increases its strength and ductility. We may forge a bar from a 20-inch ingot down to a 15-inch, and we will have a certain quality of metal on the outside, and a much poorer quality on the interior. It may be worked down almost indefinitely, each time strengthening the whole bar, but it is still better on the outside than on the inside.

Mr. RANDALL. Is that the reason why smaller guns can be made more secure from bursting?

Mr. EMERY. Yes, sir.

Mr. HISCOCK. The ingots can be forged down to a fine wire?

Mr. EMERY. Yes. The Cambria Iron Company, at Johnstown, Pa., is to-day reducing an ingot of 5,000 pounds weight and 18 inches square, by continued operations through rolls and drawing, until it reaches the section of, and becomes a, fine wire.

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I consider the open-hearth furnaces at Johnstown eminently adapted for this study and prosecution of the working of steel with the hope of getting more uniform and better grades. The rotation of these furnaces enables them to wash out, as it were, with proper fluxes many of the impurities of the metal, and add such quantity of carbon, manganese, or other material as may be desired.

Mr. MORGAN. In washing metal, is it also melted?

Mr. EMERY. Yes, it is washed by this stirring and working of the melted metals and fluxes together.

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Mr. MORGAN. Is it a fact that when you get 1 per cent. of carbon into a bar an inch square, we will say, it becomes uneven in its texture and will draw out more in one place than at another or is softer in one part than another? If so, is that because the metal will not combine with more than 1 per cent. of carbon?

Mr. EMERY. The 1 per cent. is an arbitrary per cent., which applies to one kind of steel and not to another. In crucible steel, what would correspond to 1 per cent. might correspond to three-fourths of 1 per cent., or even less, in the open-hearth steel. More carbon can be combined with safety in the crucible steel without making it hard and unequal in spots than in the open-hearth and Bessemer steels.

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Mr. MORGAN. Where is the boundary line between steel and iron?

Mr. EMERY. There is none. Steel is simply wrought or pure iron, with carbon and other impurities mixed therewith. Some people have said that iron was steel whenever the combined carbon was sufficient in quantity to cause it to harden by cooling it suddenly. I have some cold-rolled steel so soft that it is rolled out to four-thousandths of an inch in thickness and has so little carbon and is so soft that, while it is worked out into this thin plate, and therefore very highly worked metal, it has a tensile strength of only 80,000 pounds to the square inch. Yet this same plate has sufficient carbon to enable it to be hardened to

fly into pieces when bent, as would a plate of glass. By tempering, after it is thus hardened, it becomes very tough, sufficiently so to have a tensile strength of more than 300,000 pounds to the square inch.

Mr. MORGAN. Why do you call that steel?

Mr. EMERY. Because it is steel. It is made by the same processes that make steel and has its quality of hardening. Of the processes of refining steel, the first is to roll it or hammer it; the second is to temper it. Those two processes have been in vogue since the Egyptians put up the Pyramids, and I know not how much longer. Another process is that of compression. Steel, made by any process, when poured into molds solidifies first on the exterior, and produces, subsequently, by contraction, holes and porous spots in the interior. The gases contained in it also produce porous spots. The ingot will cool first next to the walls of the mold, as they rapidly carry off its heat. The shrinking of the ingot, as it solidifies, is very great and forms a large open space or spaces at or near its central axis, more of these spaces being towards the central and upper portion of the ingot than elsewhere.

Mr. BUTLER. Is it a hole?

Mr. EMERY. Yes, an open hole or holes, with or without an open passage through to the top of the ingot, but more frequently a series of holes, more or less of them joined together by small openings, or partially connected with each other by smaller ones. It might be in an ingot 2 feet in diameter, big enough to put your arm in.

Mr. ALDRICH. In the center?

Mr. EMERY. Yes, sir, and upper portion. And it may have all through it, but more likely in spots near the surface, blow-holes from the smallest possible size to half an inch in diameter.

Mr. BUTLER. At what stage of the process are these holes made?

Mr. EMERY. While the metal is solidifying. The ingots often have cracks clear, or part way, across their faces. The corners cool first, resisting the contraction of the parts between them and causing the whole face to crack. In the shrinkage produced while solidifying, the surrounding parts must come together or else tear the contracting part in two, and hence these ruptures. If, as soon as the ingot is poured into the mold, the mold is very strong, and before solidification has taken place to any great extent, sufficient pressure is put upon the liquid metal to cause the plastic part already solidified and the liquid part not yet solidified to be in close embrace and is retained for a few minutes, the whole mass solidifies as one, without these open blow-holes and porous spots. In addition to those caused by shrinkage, there are the holes caused by gases held in the metal at the time of pouring or formed therein immediately after. The ingot made contains these in any and all parts, but the surface is not likely to show them. They will be found on cutting into it. Castings in various forms for use without forging will usually contain more or less of these gas-holes, which usually have a smooth wall surrounding them and occur in greater frequency on the upper side of the casting than elsewhere.

If the casting is solidified and cooled under heavy pressure in the hydraulic press these gas-holes, or blow-holes, as they are ordinarily called, will, with the shrinkage-holes, almost entirely disappear. The gases, for instance, which occupy a cubic inch when under one atmosphere of pressure, would occupy but one-thousandth part of a cubic inch when under a pressure of 15,000 pounds to the square inch, or one thousand atmospheres. Under such reduction these blow-holes become so small as practically to disappear. This pressure, when thus used,

produces what is called liquid compressed steel, or fluid compressed steel, which has no cracks, seems to be in closer union and harmony throughout, and to be more uniform, and is much stronger than steel not so pressed. In the case of the soft steels the ingot could be pressed together after it had become cold, and, while cold, if sufficient pressure were used, these holes would be reduced in size, and might, with sufficient pressure, be almost annihilated; but their walls would not adhere, and the metal would not be as uniform or as strong as if it had been pressed in the liquid or pasty state. When the metal is not thus compressed the ingot is always strengthened very greatly, either by hammering or by hydraulic pressure while it is red-hot. The ingot may be allowed to cool and be reheated, or it may, by the use of the soaking-pit, retain and equalize its own heat sufficiently to be treated by the hammer or rolls to condense it and close up the spots; but the strength in those parts where the large cavities were or where cracks were will not then be as great as if it had been compressed in the pasty or fluid state. But whether compressed in that state or not, further working of the ingot in the heated state by the hammer or rolls increases its strength, and the more it is so worked the greater its strength is made.

Annealing the ingot will improve its quality, and tempering it in oil will make it still stronger. If the ingot is drawn out under the hammer or rolls into a bar or plate its ductility, strength, and limit of elasticity will be much greater than the metal cut from the ingot, but the difference will not be marked if the ingot was compressed while hot.

If hammered or compressed cold, its strength and limit of elasticity will be very much increased, but its ductility will usually be somewhat decreased.

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Mr. HISCOCK. I have seen somewhere that, at some point, there is an action of the steel they call flowing. What is that?

Mr. EMERY. If this bar of steel [illustrating by cane] was melted it would flow from the force of gravity, and if I held it vertically [illustrating] it would flow down, no pressure being required; but if heated to bright red only, its own weight would not cause it to flow, but a few pounds pressure would. If cold, a larger pressure would still cause it to flow or shorten, settling down together by flowing out laterally in every direction, just as wax would flow by pressing it. Ordinary wrought iron will flow quite sensibly with a pressure of 30,000 pounds to the square inch, beginning to flow slightly with from 20,000 to 22,000 pounds; the flow being quite rapid with 40,000 or 50,000 pounds to the square inch. The low steels which break with a load of from 50,000 to 55,000 pounds to the square inch begin to flow with a pressure of 30,000 or 35,000 pounds to the square inch, and have a tendency to flow with a pressure of 50,000 or 60,000 pounds to the square inch, and would be forced rapidly out of dies, open at one end, if the pressure on the sides was equal to 70,000 or 80,000 pounds to the square inch. Higher steels require more pressure to cause them to flow, but they will all flow under sufficient pressure, unless they have so much carbon or are so highly tempered as to crack, when they fly into pieces instead of flowing.

To pass to ordnance in its practical forms, in this Krupp gun [exhibiting drawing of gun to the committee] there is one massive piece of steel forming the barrel, surrounded by numerous bands to strengthen it. The mass of this steel for a large gun, say 14-inch, is very great, being in the rough ingot perhaps 60 or 70 tons. The Krupp hammer of 50 tons, falling 10 feet, produces a blow of 500 foot tons. This, on this massive ingot, is not sufficient to properly work or refine it, and Mr.

Krupp finds it necessary to build a heavier hammer for the production of the larger guns that he is making.*

By hammering these large guns with too small a hammer they are not sufficiently condensed anywhere, and especially in the interior. Even this larger hammer, when done, will not work the interior so much as it should be done. The very poorest of the metal is bored out to make the bore of the gun, and that which is left next to the bore is still the poorest part. At the same time this enormous body is of such proportions and thickness that it cannot be well oil tempered, and this greatly beneficial process is of little avail in such large masses when thus proportioned. The exterior of his gun, that is, the parts which form the bands, may be well worked of a high grade of steel, and tempered to still further improve it, and then put on with a high strain of tension caused by forcing on the bands with a press, or by cooling and shrinking on the barrel.

Considering the gun which our own War Department contracted for, under an appropriation made especially for four 12-inch breech-loading guns three years ago [exhibiting drawing to the committee], the barrel was made of coiled wrought iron welded together in short sections, the parts being partly dressed, and then welded together by hydraulic pressure, and the whole finished as one piece ready to insert in the steel breech receiver. These barrels were made at the West Point Foundry, and nearly finished, when work was suspended by the order of the Department. This breech receiver, which is made of steel and constitutes a jacket inclosing several feet of the rear part of the barrel, was, I am informed, too large to come within the capacity of Whitworth's factory, and he declined to estimate on it.† Firth was the only one who made a satisfactory estimate, and the contract that was awarded to him required that the metal should stand 90,000 pounds tensile strain to the square inch. Unfortunately for Mr. Firth, his hammer is only 25 tons, while the ingots for these receivers required, to properly forge them, a hammer of 100 tons with more than twice the fall of his. The effect of Mr. Firth's light hammer was that even the smaller forging for the 11-inch gun, made by him in the same way, proved so inferior that it burst at the third fire through here, near the face of the breech-block [illustrating]. The 8-inch gun made in this way burst through here [illustrating] at the eighteenth fire. The Firth hammer has to strike a sharp, quick blow so as to condense the forging by impact, not having the requisite weight to compress it with the slower blow. The sharp, quick blow from the light hammer may condense the exterior, but will not forge the mass through and condense the interior as will the heavier, more slowly-moving 100-ton hammer, and still less than the quick-moving 100-ton hammer falling through a larger space.

Mr. BUTLER. Is there a plant or establishment in this country able to make those receivers?

Mr. EMERY. Not to forge or compress them.

Mr. BUTLER. We have no forges in this country to make that part of the gun?

Mr. EMERY. No, sir.

The CHAIRMAN. How large a gun part could we make?

Mr. EMERY. Possibly two pieces large enough for the 8-inch gun.

The bursting of the 11-inch and 8-inch rifles caused the Army Ordnance Department to feel uneasy. The subsequent testing of the metal provided for the 12-inch rifles showed a strength running from 60,000 pounds downwards, instead of running up to 90,000. The result was that, while the barrels were made, and the steel all made and rough

* See page 466.

† A mistake. Whitworth & Co. inform us they were not asked to offer bids. August, 1885. (Chairman.)

dressed for the receivers, bands, and breech-blocks, they were condemned entirely, and never completed. The guns are not made.

Mr. ALDRICH. Those are the guns ordered a few years ago?

Mr. EMERY. Yes, sir; three years ago.

Mr. BUTLER. Do you know the cost of that experiment?

Mr. EMERY. No, sir; I had most of the figures, but do not bring them to mind. The amount expended on the 12-inch rifles was about $32,000 to make the wrought-iron barrels; the steel for these four guns, as imported, cost about $50,000 previous to putting any work on it at the foundry here, where some money was expended. The gun body was to be made at the South Boston Foundry. The Department expended—or the South Boston Foundry expended, the Department furnishing the money—some $60,000, or more, for plant to make these guns. The castings for the gun body were not made, as the work was suspended before the bodies had been cast.

Mr. BUTLER. Is it entirely practicable to have the necessary forgings made and put up in this country for making these pieces?

Mr. EMERY. Yes; but it is not advisable to make a 12-inch rifle in this way.

Mr. BUTLER. But with the expenditure of enough money, forges could be put up in this country. What would be the cost of them?

Mr. EMERY. The New York Times published the following:

The Secretary of State has received from Consul Potter, at Crefeldt, Germany, a report on Krupp's steel ordnance works at Essen, from which the following extracts are taken:

The forging process requires vast arrangements on account of the immense weight of the pieces which are to be handled, one of which weighs sometimes more than 60 tons. The steam-hammer, now in use for this purpose, weighs 50 tons, and has a stroke of 10 feet. Another hammer is now being constructed of much greater efficiency, weighing about 150 tons, which will cost 10,000,000 marks, or $2,500,000.*

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Mr. Krupp is now engaged in constructing 40 centimeter (16-inch) guns, of 35 calibers in length, weighing 121 tons, for the Italian Government. Ten of this latter description, it is stated, have been ordered at a cost of 894,000 francs each, for the purpose of coast defense.

The CHAIRMAN. What is to be the fall of the Krupp 150-ton hammer?

Mr. EMERY. I do not know.

Mr. MORGAN. The two and a half millions you say covers the cost of the cranes and furnaces, together with the hammer?

Mr. EMERY. It covers nothing for making the steel; only the forging of it.

The CHAIRMAN. That cost is for the hammer, its cranes, and heating furnaces only.

Mr. EMERY. Yes, sir.

Mr. MORGAN. Don't you think it is very much overestimated?

Mr. EMERY. No; I think not. The foundations for the hammer are very heavy and expensive.

Mr. MORGAN. What is the material used for the foundation?

Mr. EMERY. A great mass of cast iron constitutes the anvil-block, which rests on a large bed of wood and masonry, piles, &c.

Mr. BUTLER. What is the size of the largest hammer in this country?

Mr. EMERY. Seventeen tons. It is at Park Brothers, Pittsburgh.

Mr. MORGAN. In constructing the hammer, there is no forging for it?

Mr. EMERY. It is mainly of cast steel or cast iron, usually the latter.

Mr. MORGAN. We could make a large hammer here?

Mr. EMERY. We can make anything here, if you pay us for it.

The hammer at Le Creusot weighs (the metal work) twenty-seven or

*Later information leads us to believe that Krupp is doing nothing toward this hammer, but rather turning attention to powerful hydraulic forges. (Chairman.)

twenty-eight hundred thousand pounds. But if I were going to build a hundred ton hammer, with 20 feet fall, I would put more metal in the foundations. It would be more stable.

The CHAIRMAN. Explain the construction of the anvil-block.

Mr. BUTLER. How much would you make it weigh?

Mr. EMERY. One thousand tons.

Mr. BUTLER. Is that metal?

Mr. EMERY. Yes, sir; metal on which the anvil proper rests. This anvil itself should be of a stronger and better class of metal than would be required for this large base.

Mr. BUTLER. Does it or not require to have a very strong piling under that to prevent shaking?

Mr. EMERY. Several years ago Mr. Krupp prepared plans for, and commenced the construction of, a hundred ton hammer, but never completed it. The foundations for that were 90 feet deep; he is now constructing a larger one.*

Mr. BUTLER. What does he put in that foundation?

Mr. EMERY. A great mass of masonry and piling; a great mass of timber, and then a great mass of metal.

Mr. MORGAN. The timber is to give it spring?

Mr. EMERY. Yes, sir.

If a two million pound casting instead of one is used for the base of the anvil it will stand and, by its own inertia, receive the blow, and the whole hammer, foundations and all, will be much less disturbed than when it is lighter. It is evident that the smaller the mass of steel the better the quality. no matter how it is treated.

Mr. BUTLER. How do you temper steel?

Mr. EMERY. Heat it bright red and plunge it into any kind of oil (linseed and sperm being among the very best for this). The cooling is less sudden than when plunged into water, and the steel is not hardened so much as when plunged into water, or acid water, which hardens it still more. This cooling in oil refines and gives it a finer and closer grain. It is much stronger, its limit of elasticity and ultimate strength are raised, but its ductility is somewhat decreased, and will be largely so if it is cooled very quickly.

Mr. BUTLER. What is the temperature of the oil?

Mr. EMERY. It should be cold.

Mr. BUTLER. Why oil instead of any other fluid?

Mr. EMERY. Experience has shown that it gives the best results. The parts are not so brittle when tempered in oil. They are left tougher and more ductile, and are more evenly tempered through than if tempered in water.

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Mr. MORGAN. If you are through with descriptions of the different processes, I want to ask you a few questions about your testing machine.

Mr. BUTLER. One other question on that point. The tendency of your remarks appears to indicate that the object is to get as large ingots as possible. But if I understand your conclusions, they are that the smaller you get the ingots the better you can work.

Mr. EMERY. Get the ingots as large as your tools can work them, and then work them down to the smallest parts that will do to build up the gun, as we have seen the smaller these parts are made the greater is their strength.

There must be a few main pieces, constituting when bound together, the body and barrel of the gun; and these may be strengthened by

* See page 466.

numerous smaller pieces, sufficiently worked to have very high elastic and ultimate strength.

Mr. BUTLER. What is the limit of reduction that gives the greatest strength?

Mr. EMERY. It has not yet been found.

Mr. BUTLER. You just keep working them down?

Mr. EMERY. Yes; to a fine wire or very thin sheet. For instance, I have taken cold-rolled steel, rolled into a plate thirteen thousandths of an inch thick, and half an inch wide, which is thus highly refined and hardened by mechanical work put upon it, and then tempered. This plate so treated broke under a load of 314,800 pounds to the square inch. It will probably never be possible to make large pieces, suitable for guns, with such degree of strength. If so, we might fill the powder chamber with powder, put in a shot and fasten it there, burn the powder and leave the gases any length of time, a day or a year, and then loose the shot and let the powder propel it without firing, it having been fired the year previously. Professor Treadwell did, several years ago, get a small piece sufficiently strong to hold a charge of powder, thus confined in a bore, perhaps a half inch in diameter, which he fired and left there many hours, and then allowed the gas to escape by opening a vent.

Mr. Woodbridge undertook several years ago to build a wire gun, and such a gun was built out of the appropriation for testing ordnance in 1872. A large sum of money, some $50,000 or $60,000, I think, was spent to produce a 10-inch gun on his plan. This gun consisted of a steel tube, which constituted the barrel of the gun, around which was wound a mass of steel wire sufficient to constitute the body of the gun. The whole mass was then brazed together, which process spoiled the refining of the steel, as it was so far annealed during the long process of brazing as to weaken the metal. The gun was inferior in strength to the ordinary solid cast gun, made of charcoal iron from the air furnace. Tests of the metal from this gun, and its bursting after firing something like one hundred rounds, proved this. The gun was fired with charges considered small for a steel gun, and was then torn in two transversely, showing it to have very small longitudinal strength, practically not half that of the cast-iron gun.

Mr. BUTLER. Is there any arbitrary form for ingots?

Mr. EMERY. No, sir; at Le Creusot they are made about 5 feet in diameter and weigh 60 tons. The ingot is forged under an immense hammer, from a mass 5 feet square, into armor plates from 1½ to 2 feet thick, as occasion requires.

Mr. BUTLER. What is the form of the ingot?

Mr. EMERY. Sometimes cylindrical, but usually rectangular, the section being most frequently square with rounded corners. The curvature of these corners is from 10 to 20 per cent. of the diameter of the ingot, and the length of the ingot usually 4 or 5 diameters. The larger the ingot the more work must be put upon it to bring it down, and the more work put upon it the greater the refining.

Mr. BUTLER. Your idea then is to work it down to the smallest practical size.

Mr. EMERY. Yes. And when these highly refined parts are assembled, to have tension on the parts constituting the exterior, and compression on those parts which constitute the interior of the gun. The strains at the interior will be in the reverse of those given by the powder, in that part of the gun, and hence aid in opposing the powder strains.

Mr. ALDRICH. Do you not think you could get the same results by compressing the liquid ingot with the hydraulic press that you get by forging with the hammer.

Mr. EMERY. It is not possible in some instances, and it is better done in others.

Mr. ALDRICH. In what case would you use the hydraulic forge?

Mr. EMERY. In those cases where a great number of pieces of one exact size and form were required, so that dies would be prepared in which these pieces would be compressed with great force. But the hammer is better adapted to a great many pieces with special dies, and it will do a great many things that the press will not do.

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Mr. HISCOCK. How much do the ingots shrink?

Mr. EMERY. Whether the steel itself, aside from blow holes, is denser by hammering, is an open question to-day. There are some things that would make it appear that the refining by hammering or by tempering does not increase the density.

The CHAIRMAN. Do you mean to say you cannot distinguish the difference in specific gravity between steel completely treated and ingot steel?

Mr. EMERY. This matter has not yet been well determined, but recent experiments, carried on very extensively by M. Spring, go to show this. He used pressures running from twenty to nearly thirty thousand atmospheres, or from three to over four hundred thousand pounds per square inch; and, after some years experimenting, leaving these pressures on in some cases hours, in some cases days, and in some instances weeks, he concluded that as soon as the pores, or spots occupied by the gases, are closed up there is no further condensation of the metal; or, in other words, that the metal itself is not at all condensed by the pressure, but that all that the hammering or pressure can do to increase the density is simply to close up the holes or porous spots, leaving the metal itself in close compact.

At the Crescent Steel Works, in Pittsburgh, the crucible steel, rolled out, goes into machines which have a series of rotating hammers running at very high speed, the rods passing through them until they come out so smooth and uniform that you cannot tell by handling and observation the difference between them and drawn wire, but in quality they are more highly refined and better; and when thus hammered and drawn out will, by tempering, be still further refined, and give the best quality of steel yet known.

Mr. MORGAN. Does the rod get hot under the hammers?

Mr. EMERY. Warm, but not hot. You can take it in your hand.

Mr. MORGAN. You are the inventor of the Watertown testing-machine, I believe?

Mr. EMERY. Yes, sir.

Mr. MORGAN. How many different tests of metal can be made upon that machine?

Mr. EMERY. The machine is prepared to test specimens for tension or compression on all lengths up to 28 or 30 feet, and of any load from 1 pound up to 800,000. It is also prepared for testing short specimens only with transverse loads. I have devised transverse apparatus for large long beams, and have designed torsion apparatus for all sized shafts up to those of the largest steamboats, by which they could be tested and their qualities found without injuring the shafts.

Mr. MORGAN. The test for shafting, your present machine does not make?

Mr. EMERY. It does not. That will require a separate machine. The new machine is not ordered. Estimates were put in for torsion apparatus and transverse apparatus for each of the last two years, but the appropriation committee did not report them.

Mr. MORGAN. With this present machine you cannot give torsional tests?

Mr. EMERY. No, sir.

Mr. MORGAN. After you had completed that machine you turned it over to the Government?

Mr. EMERY. After I completed it, and while I was setting it up, Congress passed a law instructing the Secretary of War to use it for every person who should apply.

Mr. MORGAN. It is not now under your management?

Mr. EMERY. I have no more to do with it than you have.

Mr. RANDALL. You still have some pretty anxious inquiry over it. You look over it occasionally?

Mr. EMERY. I have been there several times.

Mr. RANDALL. Has the field of experiment with the machine been a very wide one?

Mr. EMERY. The field of experiment has been to make tests for private parties and for the general information of the public. The latter is in my estimation highly commendable. Some parties think the Government should not do that for the people, but that the people should do it for themselves. I disagree with them. As regards private tests there are two sides to the question. It is of advantage to the individual to be able to go and make these tests and find how to do his work without having to provide his machine; but it works great injustice to me, as the inventor, as only about a fifth of the actual cost of the machine was paid me, and this free use by private parties tends to prevent my selling other machines. Under this law passed by Congress the use of the machine was made free to all individuals, they merely paying the direct cost of running the machine while their tests are being made, no charge being made for its use.

There have been tested brick for the new Pension Office, foundations for the Washington Monument, and various building stones; also a large mass of timber. Some columns were tested with sections as large as 14 by 16 inches, and these large columns were crushed longitudinally with from a third to a fifth of the strength credited to them in many engineering works, where the results were based upon tests of small pieces tested in small machines.

There have also been tested a great variety of iron for bridges, and a great many specimens of boiler plates; many tests of parts of the East River bridge, and of bridges for the Pennsylvania Railroad, have been made. Some of these bridges had been up a number of years, and it was wished to discover whether they were sufficiently strong to carry safely some heavy locomotives that were being made. Short links of similar material, section, and form, except as to length, were made and tested so as to give an accurate knowledge of what the longer links of similar quality and like section would bear, and to determine what those bridges, which were up, would bear without injury.

Mr. MORGAN. Do you have tests from the Pacific coast?

Mr. EMERY. I think so, but cannot say what comes from there. They come from various parts of the country, but more largely from the North, which does more manufacturing. Some specimens have come from Canada; but their tests are expensive, as the parties have to pay duties on the specimens brought in for testing. I remember one instance where

two columns sent from Canada for testing cost, for duties, freight, and testing, over $400.

Mr. MORGAN. From what part of the United States do ores come from which metals are made which gave the best results?

Mr. EMERY. There have not been sufficient experiments made by any one to give us any definite classification. In the case of some iron brought from Lake Superior during the war forty-two cannon were cast under my directions for the State of New York, and the average tensile strength of specimens from the last thirteen tested was over 45,000 pounds to the square inch, and one ran up to 49,496. These are the highest tests of cast iron known to me.

Mr. BUTLER. Could you form any idea or estimate of the cost to the Government of a test of the various ores in the different parts of the United States worked up under the supervision of an expert in metal? Suppose we wanted to have that question settled by getting ores from the various parts of the United States, the Pacific coast, and everywhere else, how much would it cost to manufacture these ores into steel, and then put them to test in your machine?

Mr. EMERY. If the steel is intended for boiler and ship plates it would be one thing, if for drawn wire another, if for merchant bars another, if for railroad bars another, steel castings and bridges another, if for ordnance still another.

Mr. BUTLER. Take ordnance, for instance, what would be the cost?

Mr. EMERY. To experiment sufficiently to properly classify the value of the ores from the different parts of the country, for any of the above-mentioned purposes, would require a very considerable sum of money; but if we take the question of ordnance, a more extended and extensive investigation would be required than for any other purpose, or perhaps than all the others put together. Indeed, the different ores would have to be worked up to make the different sized parts; in many instances they would have to be worked in large masses; and, after working, their value as guns could only be determined by extensive tests; and if the metal proved good, by the actual construction and test of the guns themselves, from the metals so worked.

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Mr. MORGAN. Our inquiry here is somewhat limited. We are trying to find out the capacity of our country to produce metal for making guns of high power, also machine-tools for the manufacture of those guns.

Mr. EMERY. The Cambria Iron Company, at Johnstown, Pa., is not only able to produce, but *is now* producing five or six hundred tons of steel per day.

Mr. MORGAN. Is that steel of quality suitable for making guns of highest possible power?

Mr. EMERY. Not a pound of it. The Cambria furnaces are well adapted to making steel for ordnance, but for this purpose men are required specially skilled, by past or future training, to use these furnaces in making the special quality of steel desired.

Mr. ALDRICH. Are they open-hearth furnaces?

Mr. EMERY. Yes; open-hearth, rotary furnaces.

Mr. MORGAN. You State your opinion that in Johnstown steel could thus be made in any quantity to give the highest possible quality of gun?

Mr. EMERY. Yes; steel to go through the process of treatment which I have mentioned, making it fit for the highest quality of ordnance. There are also many open-hearth furnaces, both rotary and stationary,

at several other places where only suitable men of experience would be required to produce steel suitable for making parts of ordnance.

Mr. MORGAN. In other words, we have the ore and plants, and we can make steel suitable for ordnance; but would, of course, require some experience in using these plants in the production of steel especially suitable for ordnance, before such steel would be produced.

Mr. EMERY. We have everything requisite for making a much more powerful gun than the world has yet produced, except the consent of Congress to provide money continuously, in sufficient quantities for ordnance, to induce our manufacturers to put up the necessary plants to work such steel into guns.

Mr. MORGAN. I take it for granted, by the adoption of your machine by the Ordnance Board of the Army, that it is a conceded fact that it is the best and most accurate machine.

Mr. EMERY. The whole world concedes that.

Mr. MORGAN. Therefore the tests made by this Board were not as complete as if they had been made on your machine?

Mr. EMERY. Not one of those tests were made on my machine.

Mr. MORGAN. I want to know if these tests are as accurate as they would have been if made on your machine?

Mr. EMERY. No; I believe in many instances they were very unreliable.

Mr. MORGAN. I want to know whether, in our investigation, we should predicate our observation on the result of tests made by this Board for testing steel and iron.

Mr. EMERY. I would only predicate them on metal which I knew to be like that tested.

Mr. MORGAN. We want to get at something that will inform us as to the capacity of our country for making guns, and we want to select the best places for establishing Government works. It is for that purpose we want to ascertain what particular places the metals came from which were used in those tests.

Mr. EMERY. Those metals were not made into ordnance, and do not, therefore, give you the information applicable to guns.

Mr. HISCOCK. Has it now reached that point that really the differences in ores are overcome by the method of handling them?

Mr. EMERY. Ores worthless ten years ago are to day serviceable for Bessemer and open-hearth steel of good quality.

Mr. BUTLER. Is it not true that the finest class of ore would make the finest class of metal, if properly worked?

Mr. EMERY. I think it would.

Mr. BUTLER. Have you ever given any attention to the difference in the cost of plants in this country and in Europe; for instance, take the Royal Arsenal at Woolwich, or Newcastle-on-Tyne.

Mr. EMERY. I would usually add our 40 per cent. tariff.

Mr. BUTLER. You mean 40 per cent. greater here than in England?

Mr. EMERY. That would, as a rule, measure the difference in cost. But taking away the duty from the metal used would not reduce the cost 40 per cent., because we still have to pay high prices for labor.

Mr. BUTLER. In other words, if we wanted to duplicate one of those plants it would cost 40 per cent. more.

Mr. EMERY. If you take Whitworth's process and add 40 per cent. you would not have such a forge as would be desirable; and even then, if it were my own case, I would surely add the hammer.

Mr. MORGAN. That is to say, you would not be willing to make the experiment of getting along without it?

Mr. EMERY. No. The making of a plant by the Government, however, stands right in the way of individuals making a plant for the production of guns.

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The CHAIRMAN. It will be a question whether it will be wise for the Government to make a portion of the plant, making contracts with private individuals for material and parts ready to be worked out. The final building of the gun could then be done by the Government.

Mr. EMERY. The question of working steel so far has usually resulted in this way: That the tools, that is the hammer, or forging apparatus, which works the steel, shall be within reach of the furnace which operates it. As a rule they should be together.

The CHAIRMAN. You mean that it is better to have the whole gun made in one place?

Mr. EMERY. Yes, sir.

Mr. BUTLER. Will not the private manufacturers want to have some assurance from the Government for a pretty large appropriation through a series of years before they would put up a plant large enough?

Mr. EMERY. I will answer that by taking my own case. As a manufacturer and inventor of ordnance I say this: If the Government will order of me one hundred 12-inch rifles, I will furnish them in six years, putting up my own plant, with the understanding that if the guns are satisfactory the Government shall take them and pay for them, but not otherwise.

Mr. BUTLER. Do you think you could do it for one hundred guns?

Mr. EMERY. I would be willing to take the risk. I will put up the plant. The money which you would have to appropriate would be, say, $50,000 apiece, or $5,000,000 altogether.

Mr. MORGAN. How would the cost compare with that of the same number of guns made at Government establishments?

Mr. EMERY. It would probably be very much less; because to produce those guns, a plant worth $2,000,000 is needed. When you have my one hundred guns, you do not pay for my plant. But you pay for the guns less than it would cost you to produce them, because private manufacturing is more economical than public.

Mr. BUTLER. How long would it take to deliver them?

Mr. EMERY. It would be one year before the first gun would be ready; six months before the next; and after that, one a month until the third year; after that, two a month.

Mr. BUTLER. In that way, covering six years.

Mr. EMERY. Yes, a million dollars a year, and you will get one hundred guns which I will guarantee to be the very best.

Mr. MORGAN. I want to know whether the manufacturers of the United States can make machine tools of as high quality in every respect as can be made abroad. I saw a statement, copied from a statement of a board of French engineers very recently, who had been on a tour of inspection in the United States to report to a society, and they report that they have to open their eyes and go to work, or the Americans would take the market away from them. Now, in making the tools that you speak of, would you make them of American or imported steel?

Mr. EMERY. Wholly, I think, of American steel.

Mr. MORGAN. Then we can produce steel in the United States suited for the best tools?

Mr. EMERY. We can produce the best steels in this country, and if

you set us to making guns we can make them as well as they can be made anywhere.

The CHAIRMAN. There is a firm in my town which has spent $30,000 in perfecting a small measuring machine. They made the discovery that there were no two standards of measurement in the world of the same length.

Mr. EMERY. The Russian Government sent some engineers to this country to look at machinery. In the course of their travels they visited the shops of William Sellers & Company, in Philadelphia. So much pleased were they with the quality and character of the tools made there, that on their return the Emperor requested them to ask the firm to give an estimate for duplicating their entire works, every tool in it. Mr. Sellers gave an estimate which was accepted. He produced a duplicate of his works and it went to Russia to be set up. So highly pleased were the Russian people that they sent by the Emperor himself a special invitation to William Sellers to come out to Russia and go under special escort throughout the Russian Empire as a Great Mogul—these last words are my own. Owing to death in his family Mr. Sellers declined to go.

The firm of Pratt & Whitney, of Hartford, Conn., spoken of by the chairman, sent three million dollars' worth of fine tools to the German Government, mostly tools for making and inspecting small arms.

STATEMENT OF COMMANDER R. B. EVANS, U. S. N.

PITTSBURGH, PA., *December* 10, 1884.

Mr. MORGAN. What is your rank in the Navy, and to what duty are you now assigned?

Commander EVANS. Commander, United States Navy; now on "waiting orders"; employed by the Baltimore and Ohio Railroad Company as inspector of bridge material and construction.

Mr. MORGAN. If you have been engaged in testing structural steel in Pittsburgh, please state for how long you have been so employed, and the character of the tests you have been conducting, and for what work the steel is intended.

Commander EVANS. I have been engaged in the city of Pittsburgh in testing steel for structural purposes since August 1, 1884. The character of the tests has been varied; chemical and physical; specimens and full-sized members. They have been mostly for the purpose of obtaining steel of proper quality for use in the railroad bridge now being constructed over the Susquehanna River at Port Deposit, Md., by the Baltimore and Ohio Railroad Company. I have also observed, in a professional way, the results of tests of steel castings for various purposes.

Mr. MORGAN. Is the steel you have been testing made of American or foreign ores or metal, and in what proportion is it foreign. Please to state the number of tests you have made, and state about the average results of those tests as to tensile strength, elongation or elastic limit, and in the other respects in which you have applied the tests. Where was the steel made and rolled or hammered that you have been testing?

Commander EVANS. The steel I have been testing was made from a mixture of American and foreign metal—about half and half. Steel of the same quality has, however, been made of purely American ores. It is simply a question of the percentage of phosphorus, and any ore or metal with .07 to .08* per cent. phosphorus can be safely and successfully used in the manufacture of structural steel. This percentage has been found in American ores, and as I have above stated, steel of the finest quality has been made in Pittsburgh from the native product.

I have made about five hundred tests of steel, with the following average results: For *compression* steel, elastic limit, 52,000 pounds per square inch; ultimate strength, 83,000 pounds per square inch; elongation in 8 inches, 20 per cent.; reduction of area at point of fracture, 45 per cent. For *tension* steel, elastic limit, 44,000 pounds per square inch; ultimate strength, 73,000 pounds per square inch; elongation in 8 inches, 26 per cent.; reduction of area at point of fracture, 50 per cent.

These results have been easily obtained in test specimens and with great regularity.

The full-sized members tested, mostly eye bars 9′ x 5″ x 1″, have averaged as follows: Elastic limit, 43,000 pounds per square inch; ultimate strength, 72,000 pounds per square inch; elongation in whole length, 17 per cent.; reduction of area at point of fracture, 40 per cent.

They were annealed in a furnace after being upset. The fractures all showed fine silky and tough, with occasional spots of silicon.

* Would give about .17 in the steel; for .08 in ore + .07 in the pig + .02 in the coal = .17 in the steel. (Chairman.)

Had the specifications called for different results from those given above, the composition of the blows could have been so changed as to produce metal of almost any required physical properties.

The steel above referred to was made by the Pittsburgh Bessemer Steel Company, at Homestead, Pa. The slabs for compression steel were hammered in Pittsburgh, and both compression and tension were rolled at the Union Iron Mills, Pittsburgh.

Mr. MORGAN. Are you familiar with the open hearth, crucible, and Bessemer processes of making steel? Which do you prefer as producing the best metal for guns of high power, either built up or cast, for boiler and ship plates, for armor plates, and state your reasons for the preference you state?

Commander EVANS. I am familiar with the different processes named.

For built-up guns the crucible steel, as manipulated by Krupp, has, up to a late date, given the best results in large calibers.

In the immediate past the open-hearth fluid compressed steel of Sir Joseph Whitworth has excelled.

For guns of 6-inch caliber and under, the open-hearth, hammered steel, manufactured in this country has proved equal, if not superior, to any made abroad under any process; and had we the necessary plant for handling large masses of steel I see no reason why we should not make guns of any desired size and power.

I am, however, firmly convinced that the gun of the future, both for sea-coast and afloat, will be a *steel cast gun;* and I regard the Bessemer process as capable of greater refinement than either of the others mentioned, and therefore the best for producing the metal for such guns as we may require, either cast or built up.

I will give two reasons only for this opinion: The more homogeneous character of properly made Bessemer steel in masses, for hammered or compressed work; and the possibility, by rabbling, of doing away with blow-holes in castings.

For boiler and ship plates I am decidedly of the opinion that they can be most surely and safely made by the Bessemer process. They can also be made by the open-hearth process, but I do not believe with the same regularity of physical properties. The making of armor plates is an unknown industry in this country, but with a proper plant, and Government aid, Pittsburgh could supply them in any desired quantity and of any desired quality.

Mr. MORGAN. Is it your opinion that steel in sufficient quantities could be produced at Pittsburgh, from American ores or metal, to supply the guns for the sea-coast and naval armament of the United States, if the proper furnaces and other appliances were erected there, and that all the steel plates could be furnished there to build a navy of, say, fifty first-class ships?

Commander EVANS. From my experience with the steel manufacturers of Pittsburgh, I do not hesitate to say that they can, with proper plant, furnish steel plates of any desired quality, of purely American ores, faster than all the ship-builders of this or any other country could use them; and gun metal, either tubes and hoops for built-up guns or castings, faster than the Government could construct, in the one case, or bore out and finish in the other.

Mr. MORGAN. Are you familiar with the subject of tempering steel in oil? State the proper heat to give the best results in such temperings, and the best oil you have found for the purpose.

Commander EVANS. I am familiar with oil-tempering. The proper heat to give the best results depends upon the purpose for which the

steel is to be used. Generally speaking, forgings and castings for guns should be raised to a temperature of 600°, a good mellow heat throughout the entire mass and tempered at that heat. Cotton-seed oil, at a temperature of 95°, has given the best results.

Mr. MORGAN. Is there any marked difference in the beneficial effects of tempering steel, whether the piece to be treated be large or small? Up to what weight do you consider it feasible to benefit steel by oil-tempering? If you could properly heat a 100-ton gun, and could immerse it conveniently in an oil bath, do you believe that it could be benefited by oil-tempering?

Commander EVANS. There is a difference in the beneficial effects of oil-tempering in favor of the smaller pieces; not, however, to an exaggerated extent. I consider it feasible to benefit steel by oil-tempering—having reference to the weight of the mass—to any extent, the limit being your capacity for handling the mass. A 100-ton gun could be properly heated by the use of natural gas, and with proper appliances lowered into a bath of cotton-seed oil, and would undoubtedly be benefited by such treatment.

Mr. MORGAN. What has been the result of your observations as to the percentage of tensile strength and limit of elongation that can be added to steel by oil-tempering?

Commander EVANS. It may be safely asserted that oil-tempering, properly done, will add 10 per cent., to the ultimate strength and 8 per cent. to the elastic limit, while the elongation will remain practically the same.

Mr. MORGAN. In tempering steel in oil, is the beneficial effect extended thoroughly throughout the body of the metal treated, or is it limited to a certain depth from the surface? Does the metal shrink when tempered in the oil bath? Does it become more dense and solid, or are the crystals more compactly arranged by this process?

Commander EVANS. In tempering steel in oil the beneficial effects extend throughout the entire mass, and are not confined to the surface or the metal in its immediate vicinity. The metal does not shrink when in the oil bath, but the heat being slowly removed, allows the particles time to arrange themselves in the most compact form, thus rendering the whole mass solid and homogeneous.

Mr. MORGAN. Can you state any chemical or physical change that occurs through tempering steel in oil? Please to state any other matter relating to this subject that you think would be useful.

Commander EVANS. I have failed, by chemical analysis, to find any chemical change in steel tempered in the oil bath. Physical changes unquestionably take place. As stated in the answer to the last question, the particles of the metal are held in suspense, owing to the slow and regular cooling, and thus have time to arrange themselves in the form capable of giving the greatest elastic limit and ultimate strength. Experiment has demonstrated this beyond the possibility of doubt.

In conclusion, I would state that, owing to the use of natural gas in the steel furnaces of Pittsburgh, a regular heat of any degree of intensity can be maintained, which necessarily gives a great advantage over other localities. One can readily imagine a receiver holding 150 tons of Bessemer steel or more kept at any required heat by this fuel properly applied, afterwards rabbled for the second time, and then run into a casting absolutely free from blow-holes. By mechanical devices which seem possible, this mass could be transferred to an oil bath, and if the heat be not what is desired it could be raised into the gas furnace above and reheated with the greatest facility, and then finally tempered.

CUMBERLAND IRON MOUNTAIN, RHODE ISLAND.

Of the various deposits of magnetic iron ore in this part of the United States, that at Cumberland, R. I., is the most extensive and valuable.

Twelve miles from the city of Providence and three miles from Woonsocket there is a vast mass of this ore, rising many feet above the level of the surrounding country, known as "the Cumberland Iron Mountain." This mountain is a homogeneous mass of iron ore, and is about 500 feet long by 150 feet wide by 104 feet high, or, in bulk, equal to about 1,000,000 tons above water-level, while, as the deposit shows an indefinite extension in depth, the quantity of this ore may be said to be practically inexhaustible. Prof. R. H. Thurston, of the Stevens Institute, Hoboken, writes of this mountain:

> The deposit is of immense extent. That portion of it lying above the natural drainage, and which may be obtained by "open working" or quarrying, and without expense for hoisting or pumping, would alone supply a smelting furnace of the largest size for a century. The quantity below ground is absolutely incalculable.

Mr. J. B. Moorhead, of Philadelphia, writes:

> I have visited the iron hill at Cumberland, R. I., several times. There can be no doubt or question as to the quantity or supply of the ore.

From the nature of the deposit the ore lying above the surface is not high in iron. Analysis shows it to contain from 33 per cent. to 40 per cent. of metallic iron, and to be richer at the foot than at the apex of the hill, so that there is reason to conclude that there is better ore beneath. Being one of the purest ores known, it is especially valuable for the manufacture of steel; and, to quote Professor Thurston again—

> The Cumberland ore is perfectly free from noxious elements, though somewhat refractory; it will furnish a very strong iron or a most excellent steel; it can be smelted within the State at a profit; it can be made directly into steel at a much greater profit; steel made from it will bring the highest price in the market.

Experiments recently concluded have demonstrated that this ore can be concentrated to 50 or 55 per cent. of metallic iron at a cost of about $1 per ton of concentrate. This, with the other items of cost, would make the total cost of a ton of 55 per cent. concentrate ore about $2 at the mines. Such ore is now selling for $8 per ton in this harbor (New York).

The most considerable deposit of soft or hematite ore in the State is at Cranston, 5 miles from Providence. Analysis shows it to be a rich ore yielding 53.40 per cent. of metallic iron, and when calcined 63.60 per cent.

Limestone of excellent quality for flux is abundant and conveniently located.

The history of the manufacture of iron in Rhode Island is not without interest in this connection:

> During the period of the manufacture of charcoal iron in this part of New England, the mixed Cumberland and Cranston ores were used in large quantity. At intervals from 1703 to 1812 cannon were cast from iron made from these ores under contract with the Government of the United States. The cannon metal was of excellent quality, and the iron from these ores equal to the best.

The chief demand for the Cumberland ore during the past few years has been from Pennsylvania, where it was found desirable as a mixture with native ores, because of the greatly increased strength it imparts to the iron. Mr. Moorhead states that they have used about 2,000 tons

of this ore. and that "using 25 per cent. improved the quality of our iron very much."

A considerable quantity has been used from time to time as "puddle fix."

With the successful development of the "Siemens direct process" in this country a new and immediate use for the Cumberland ore has arisen, which, because of the great adaptability of the ore to this process, and the very advantageous location of the mines for the manufacture and marketing of the steel, promises to make the Cumberland Iron Mountain of immense value.

In 1880 a quantity of this ore was sent to Tyrone, Pa., to be worked by the "direct process" in the then only furnace of the kind in this country. The trial was very satisfactory, "four thousand pounds of Cumberland ore yielding (without flux) 1,600 pounds of good, clean blooms." These blooms can be worked to wrought iron of great excellence and toughness under the blacksmith's hammer. The economic result of the trial was also satisfactory, the total cost of a ton of blooms produced by the crude apparatus at Tyrone being less than $30, and proved that these blooms could be produced in Rhode Island, with an improved furnace plant, for less than $20 per ton. As these blooms are worth from $40 to $50 per ton in New England, there is an ample margin for profit, or a still larger margin by working them into ingot, which can be done at a cost of less than $40 per ton of ingot steel.

In writing of this trial of the Cumberland ore at Tyrone, Mr. R. J. Anderson, the owner of the furnace, and to whom we are indebted for the successful development of the "direct process" in this country, says:

> I can safely say that the ore [Cumberland] worked and yielded well, and makes an iron suitable for making open-hearth steel, lower than can be made by any other process, and I should say that, had I an interest in such ore, I would erect rotator furnaces at once.

As related to this subject, and as showing the resources of this section, a few words may be said regarding native fuel, the above figures of cost of blooms, however, being based upon the use of Pennsylvania coal.

Information concerning the Rhode Island and Massachusetts coal field is not widely disseminated, although the development of this field and the consumption of its coal are among the great probabilities of the future.

Though some 400 square miles in extent, this field has as yet been worked in only one or two places; that at Portsmouth, on the island of Newport, being the only place of importance at this time. From this mine something over half a million tons of good coal have been taken.* The main slope of this mine is over 1,500 feet in length. The coal from this mine has been used principally for smelting copper ore.

Mr. Samuel L. Crocker, of Taunton, Mass., the producer and consumer of this coal, writes:

> For the last twelve years, since the present proprietors have been operating the Portsmouth mine, I have used in the various manufacturing establishments in which I am interested about 10,000 tons annually, besides using it for domestic purposes, and have come to the conclusion that for making steam, and for all other ordinary purposes where anthracite coal is used, it is quite equal to the average of Pennsylvania coal. For smelting of copper and iron ores it is much better than any mineral coal now known.

* Williams' "Mineral Resources" (Report Geological Survey for 1883-1884) give an annual production of 10,000 tons for last five years. (Chairman.)

Mr. A. Tower, president of the Poughkeepsie Iron Company, writes as follows:

I used several cargoes of the Rhode Island coal in the blast furnace, mixed with other coal, in 1867, and found no difficulty in working it. In charging the furnace I left off some Pittston, and substituted some of the Rhode Island. The change made little or no difference in quantity or quality of iron made.

Some years ago the late Mr. M. C. Carey, of Philadelphia, reported, after a series of experiments in a pretty large way, that the Rhode Island coal evaporated as much water per ton as the best Pennsylvania.

The best Portsmouth anthracite contains 90 per cent. of carbon. It is a red-ash coal, burning with great freedom, and a fuller blaze when once kindled than any other anthracite.

It is a very pure coal, being practically free from sulphur and phosphorus.

Recently this mine, together with others in the vicinity, has been taken up by parties well able to develop and work them to their full capacity, so that a sufficient supply of this coal for blast-furnace purposes is to be relied upon.

Explorations are also being carried on at this time in other portions of the Rhode Island and Massachusetts coal field which are likely to lead to the discovery of large and valuable beds.

With the facts stated in this paper readily susceptible of proof, showing a proximity of ore, fuel, and flux, on tide water, in the midst of a large and increasing consumptive demand for pig-metal—a conjunction of natural advantages not elsewhere found as yet in this country—it would seem that only the judicious investment of capital in the means of producing and bringing together these materials in furnace is needed to make this *tide-water locality* one of great activity and profit in the manufacture of iron and steel, and one where they can be profitably produced when "protection" shall have ceased and "free trade" been inaugurated.

The modern high-stack hot-blast furnace run at high heats renders it practicable to use ores refractory in their nature, and with such a furnace located on the shore of Narragansett Bay pig-iron of a superior quality could be produced at a total cost of less than $15 per ton. This cost would yield at present prices from $6 to $8 per ton net profit.

Taking the cost of a complete furnace plant as $250,000 and its capacity as 30,000 tons per annum, the investment would yield over 50 per cent. It is proposed to erect such a furnace this season, and the site has already been selected.

The ability to obtain at low cost rich foreign or native ores to mix with the Cumberland, if found desirable, and Pennsylvania coke to mix with the Rhode Island coal, as also the development of the modern blast-furnace practice, are among the new features which give this enterprise its present attractiveness.

Given cheap and pure pig-metal, there is no place in the United States offering so many advantages for the establishment on a large scale of steel works, iron-ship-building yards, and a national gun foundry as the locality described in this paper.

M. STANDISH.

128 BROADWAY, NEW YORK CITY,
January, 1885.

STATEMENT PRESENTING THE ADVANTAGES OF MOUNT VERNON ARSENAL FOR NAVY-YARD AND GUN FOUNDRY.

In answer to questions sent by Senator Morgan, the following replies were received from C. A. Holt, agent of the Insurance Company of North America; Richard Sheridan, jr., harbor master; D. W. Langdon, jr.; Henry Fondé, secretary Land and Development Company; A. C. Danner, president Mobile Coal Company, and H. Austill, all of Mobile, Alabama:

Senator MORGAN. What is the depth of water in the channel recently dug in the bay of Mobile to the lower anchorage, and what is the width of that channel?

Mr. HOLT. The depth of water in the newly-dredged channel available for practical purposes during the winter season is 16 feet, while in the spring and summer it is 17 feet. The width of said channel is about 115 feet.

Mr. SHERIDAN. The depth of water in the dredged channel is from 16½ to 22 feet. The width of said channel is not less than 140 feet, and varies from that to 245 feet.

Mr. FONDÉ. The average depth of the channel recently dug through Mobile Bay is conceded to be 16 feet at mean low tide, and from 17 to 18 feet at good tide. Do not know the width.

Mr. DANNER. Practical depth about 16 feet at low water, width about 100 feet, I believe.

Mr. AUSTILL. The channel is about 16½ feet deep and 100 feet wide.

Senator MORGAN. What is the tonnage, when loaded, of the largest ship that has passed through that channel since August, 1885; how many tons of freight did it take out to sea, and was it carried through the channel without difficulty?

Mr. HOLT. The following are the tonnages of the largest vessels that have passed up and down said channel since August 1885, and were carried through said channel without detention, viz: 1,217,1,220, 1,218, 1,193, 1,152, 889. Draught of water, after loading part of cargo at the city docks, averaged about 16 feet.

Mr. SHERIDAN. The largest tonnage that has passed through this channel since August, 1885, is as follows: 1,061, 1,189, 1,076, 1,227, 1,135, 1,217, 1,210, 1,079, 1,346, 1,004, 1,152, though previous to that time ships from 1,400 to 1,600 have passed through said channel. These vessels drew, when going down channel, from 15½ to 16 feet of water, and passed through said channel without detention.

Senator MORGAN. What is the distance by the Alabama River from Mobile to Mount Vernon Arsenal? What is the depth of the shallowest part of the channel of the river between those two points? What is the average width of navigable water in the Alabama River between Mobile and Mount Vernon Arsenal?

Mr. HOLT. The distance from Mobile to Mount Vernon, by the Mobile River, is about 50 miles; the depth of water to said point runs from 14 feet 6 inches to 64 feet; the average width is from 250 to 300 feet.

Mr. SHERIDAN. The distance from Mobile to Mount Vernon, on the

Mobile River, is from 45 to 50 miles, and is navigable for deep-draught ships. I cannot answer of my own knowledge the other question.

Mr. FONDÉ. The distance from Mobile to Mount Vernon Landing is 45 miles. The United States Arsenal and reservation is some 3 miles distant from the landing. Do not know the depth of shallowest place in the river channel between Mobile and the above point. With the exception of a few lumps just above the city the average depth of channel is between 30 and 50 feet; width between 300 to 400 feet.

Mr. DANNER. Mount Vernon, not on the Alabama River, but on Mobile River, is about 45 miles above Mobile, and 5 miles below the point where the Tombigbee and Alabama Rivers run together and form the Mobile River. I am informed by one of the best of the river pilots that in no place in the river between Mobile and Mount Vernon is there a depth of less than 18 feet; that for the most of the distance the depth is great—from 60 feet and up; average width about 300 feet.

Mr. AUSTILL. Mount Vernon is about 45 miles by water from Mobile. The landing for the post is about 5 miles below the junction of the Alabama and Bigby Rivers. The Mobile River is very deep and several hundred miles wide from Mount Vernon to the city.

Senator MORGAN. What is about the area of grounds owned by the United States at Mount Vernon Arsenal? What the average elevation of these grounds above the river at high water and at low water? Immediately at or near the shore, how high is the rise of the ground above high and low water in the river? What is the nature of the soil, whether clay, sand, gravel, or marsh? Is it a plain, or is it undulating? What sort of natural drainage has it? How is it supplied with water? What is the character of the forests? What sort of country surrounds the arsenal tract? and how is it timbered and watered? State whether Mount Vernon Arsenal and the surrounding country are healthy and pleasant or otherwise? Please to give your views as to the fitness of Mount Vernon Arsenal for a ship-yard for the construction of steel, iron, or wooden ships, and as a location for a foundry for casting or building heavy guns; and state any facts within your knowledge that will tend to support your opinions.

Mr. HOLT. Can't answer from personal knowledge as to elevation of grounds and surroundings at Mount Vernon. The country is extremely salubrious and healthy, and abundantly supplied with the purest of spring and creek water.

As a site for the location of a navy-yard it has superior advantages over any other point on the Gulf coast, being contiguous to the great coal and iron fields of the State, besides its proximity to the forests of woods of the greatest variety; and, being entirely removed from the possibility of an attack by any enemy from sea renders it easy of defense.

Mr LANGDON. The soil is sandy, and generally has a clay subsoil. The surface of the surrounding country is rather level, but is slightly undulating in places. The forests are mainly long-leaf yellow pine, but the river swamp, for miles above, affords oak of various species; also, ash, walnut, hickory, and other hard woods. The country surrounding the arsenal is rather barren, and is what is known as piney-woods country. The country is generally watered with clear, pure water, containing no mineral matter that would be deleterious to health or unfit it for steam purposes. At a depth from 20 to 30, or in extreme cases 40, feet inexhaustible streams are found to supply wells.

Mount Vernon presents many recommendations as a naval station (provided, of course, that the channel of the bay is so deepened and

widened to permit of the passage in and out of vessels of heavy tonnage).

The extensive coal and iron fields, drained by the Cahawba River, can by a very short road be placed in connection with the Alabama River. By the building of this road coal could be delivered at $2.50 per ton, and iron at a correspondingly cheap rate.

Mr. FONDÉ. The United States Government has a reservation at Mount Vernon of some 320 acres. The arsenal grounds must be at least 200 feet above the river at ordinary water. The shore at Mount Vernon landing is some 15 or 20 feet above mean high water; no freshets ever overflow the bank there. The soil in the vicinity is a sandy loam with clay subsoil; best possible natural drainage. The reservation is surrounded by an inexhaustible forest of long-leaf pine. Hummock lands of the river are heavily timbered with white oak, hickory, cypress, and other woods specially adapted for ship-building. The Government records are the best evidence of Mount Vernon's health record; it can't be excelled anywhere. The water is clean, pure spring, and free from mineral or vegetable matter.

Mr. DANNER. I don't know how much ground is covered by the Government reservation. I judge the elevation on the bank of the river to be from 50 to 75 feet above high water, running back to an elevation of perhaps 150 feet; soil is sand and gravel, with clay subsoil; surface somewhat undulating, with fine natural drainage, supplied with water by wells and springs. Forests of long leaf yellow pine, with live oak, water oak, white oak, ash, and black-jack, are scattered about the country. There is a fine timber and farming country around, well watered, climate very healthy, without the extremes of heat or cold. I have long considered Mount Vernon as the most eligible point for a Government ship-yard and gun foundry in the Gulf States, and came to this conclusion after I became acquainted with other points that have been mentioned in this connection. I cannot undertake to give an account of all of the advantages possessed by Mount Vernon for this purpose; but will allude to some: The comparative ease with which it could be defended in the event of war; the accessibility of it from the sea through Mobile Bay; the purity of the water, free from salt; its healthfulness; but above all the fact that it is possible to place there any quantity of iron and coal at prices perhaps lower than these necessary articles can be placed at any other point suitable for the purposes of a navy-yard. A railroad is now projected that will pass direct from the neighborhood of Mount Vernon to the coal fields of Alabama; but in addition to this means of transportation it will be but a few years until fleets of coal barges will pass Mount Vernon on the way to the Gulf. Then coal can be furnished there at a cost of about $1.50 per ton, and pig-iron at from $12 to $14 per ton. These and the necessary wood for all the purposes of manufacturing can be delivered there at a minimum cost and free from exposure to the sea, or risk of interference by the vessels of an enemy in event of war. New Orleans, Mobile, and Pensacola might fall into the hands of an enemy with a navy strong enough to capture them, and Mount Vernon be defended by land forces beyond possibility of capture.

Mr. AUSTILL. I don't know how much land the Government owns about the post, but land there is very cheap, and as much could be purchased as may be wanted. The soil is sandy and gravelly, and is not suitable for agricultural purposes. The post stands back about a mile, perhaps less, from the river. The open piney woods extend to the river, where the landing is situated. The bank is high—never overflows—and

there is a gradual ascent from the landing to Mount Vernon. There are a number of springs in the vicinity of pure, freestone water. The tract is surrounded by pine timber, very little oak, and some hickory. The location is perfectly healthy. It is well known that even yellow fever will not spread in the piney woods. My home is at Spring Hill, a village only 7 miles from the city, and yet the place is never visited by an epidemic, though persons sojourn there in numbers when there is sickness in the city. As a location for building ships of wood or iron, and for casting guns, there could not be found near the Gulf coast a point possessing more natural advantages. The Coosa, Tallapoosa, Black Warrior, Little Bigby, and Sipsey Rivers, coming together at different points, all flow into the Mobile River only a few miles above Mount Vernon. Woods of all kinds, suitable for ship-building, grow along these streams in inexhaustible quantities. Coal and iron will soon come down them in barges, and could be delivered there for less than at any other point suitable for such work. There is a large, deep lake opening into the river in the immediate vicinity, where docks of any capacity could be built.

Vessels of any draught could be built there, and, if necessary, could be floated over the shoal water in the upper part of Mobile Bay to deep water.

At the mouth of Mobile River a harbor can be easily made of 30 feet draught, or deeper if desired, and no doubt the tide of commerce that will soon turn this way toward South America and the Pacific country, via one or both the commercial highways across the Peninsula, will require the establishment of such a harbor.

The mouth of our bay can be reached from Mount Vernon by rail in three hours, and by water in six or seven. Mount Vernon would be safe from an attack by deep sea-going ships with long-range guns, and yet would be near enough to the sea-coast for all practical purposes.

"The Gulf of Mexico will soon be the greatest receptacle of the world's commerce," and the Government will, no doubt, find it necessary to establish somewhere a strong arsenal and ship-yard. Nature points to Mount Vernon as the spot for such location.

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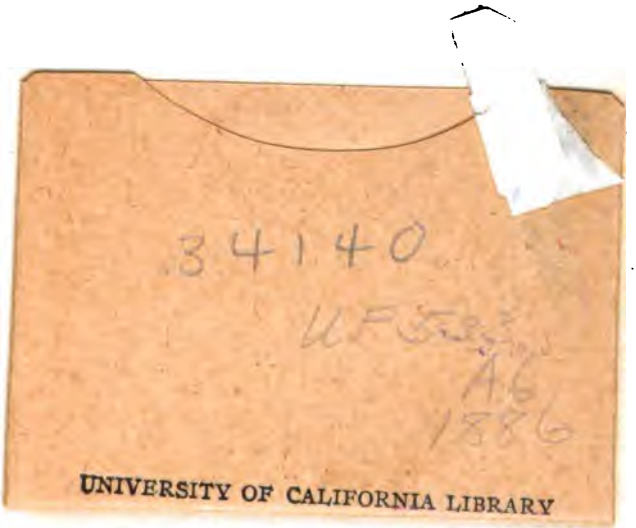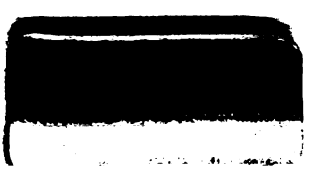
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